TV-63 Cole's Bayou Marsh Restoration Project
Coastal Wetland Planning, Protection, and Restoration Act PPL 21

95% Design Report

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Table of Contents

Tables

Page No.

Figures

Page No.

Appendices

1.0 INTRODUCTION

The Cole's Bayou Marsh Restoration Project (herein referred to as TV-63) is located in the Teche-Vermilion Basin between Little Vermilion Bay and Freshwater Bayou as shown in Figure 1. The Louisiana Coastal Wetlands Planning, Protection and Restoration Task Force designated TV-63 as part of the 21th Priority Project List. The National Oceanic and Atmospheric Administration's National Marine Fisheries Services (NOAA/NMFS) was designated as the lead federal sponsor with funding approved through the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) of 1990 by the United States Congress and the Wetlands Conservation Trust Fund by the State of Louisiana. The Louisiana Coastal Protection and Restoration Authority (CPRA) is serving as the local sponsor and will also be providing engineering and design services.

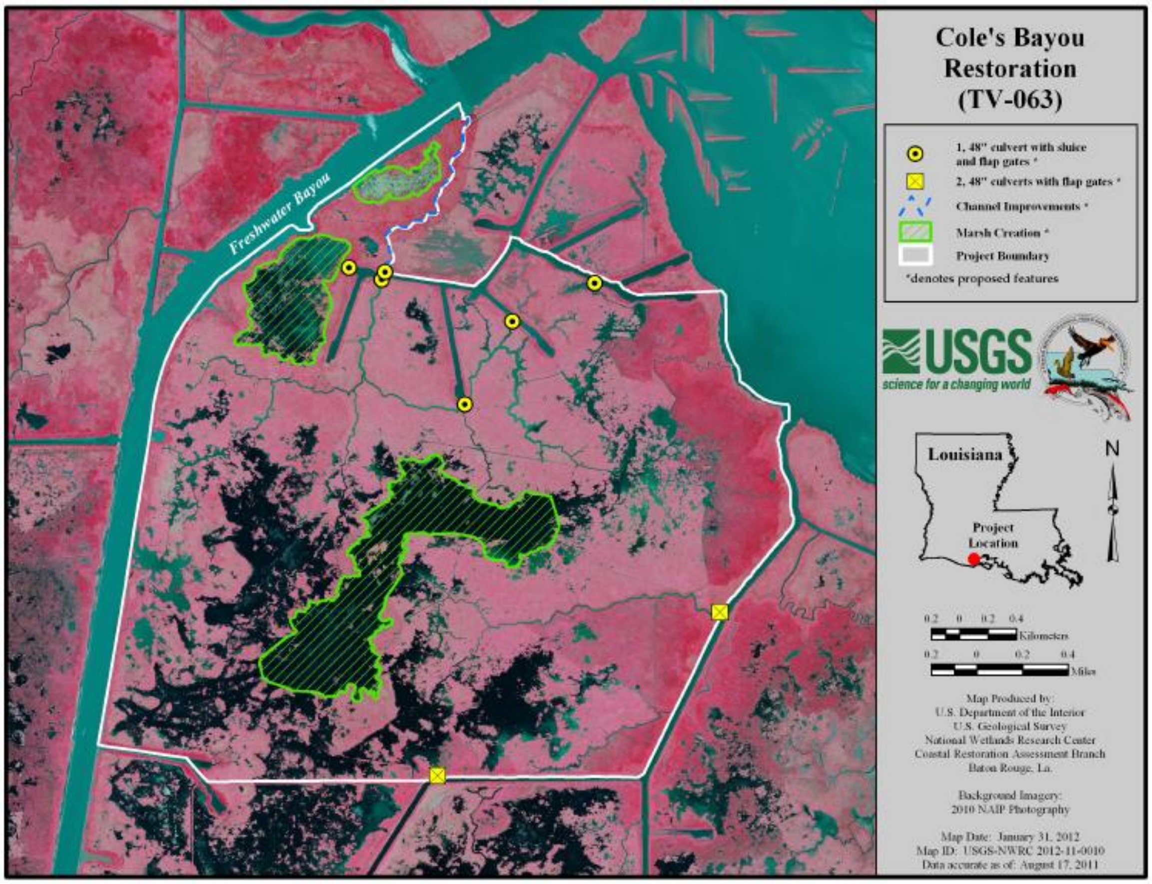


Figure 1: TV-63 Vicinity Map

The primary goals of TV-63 are to create and nourish approximately 418 acres of low salinity brackish marsh in recently-formed shallow open waters adjacent to Cole's Bayou with sediment dredged from Little Vermilion Bay and to improve the project area hydrology by reestablishing the historic freshwater and sediment patterns into the interior wetlands.

The poor condition of this marsh is due to a combination of subsidence, hurricane induced interior ponding, sediment deficiency, and changes in hydrology. The project area has undergone recent hydrologic changes through the construction of navigation channels and oil/gas field channels, resulting in earthen levees, which led to the impoundment of the area. With time, several breaches have occurred along the navigation channels and the oilfield network.

The project team, consisting of members of NOAA/NMFS, CPRA, Vermilion Parish Government, and the McIlhenny Estate, performed an on-site kick-off meeting on April 30, 2012. Based on that meeting, a plan was developed to identify and address all of the project goals and constraints. The engineering and design, environmental compliance, real estate negotiations, operation/maintenance planning, and cultural resources investigation have been completed to the final (95%) design level as required by the CWPPRA Standard Operating Procedures Version 22.

2.0 LANDRIGHTS AND CULTURAL RESOURCES

The project area is mostly situated on land owned by the E A. McIlhenny Estate. However, the westernmost portion of the project area is owned by Exxon Corporation. The National Audubon Society Rainey Refuge owns the land directly to the South and Southeast of the project area as shown in Figure 2.

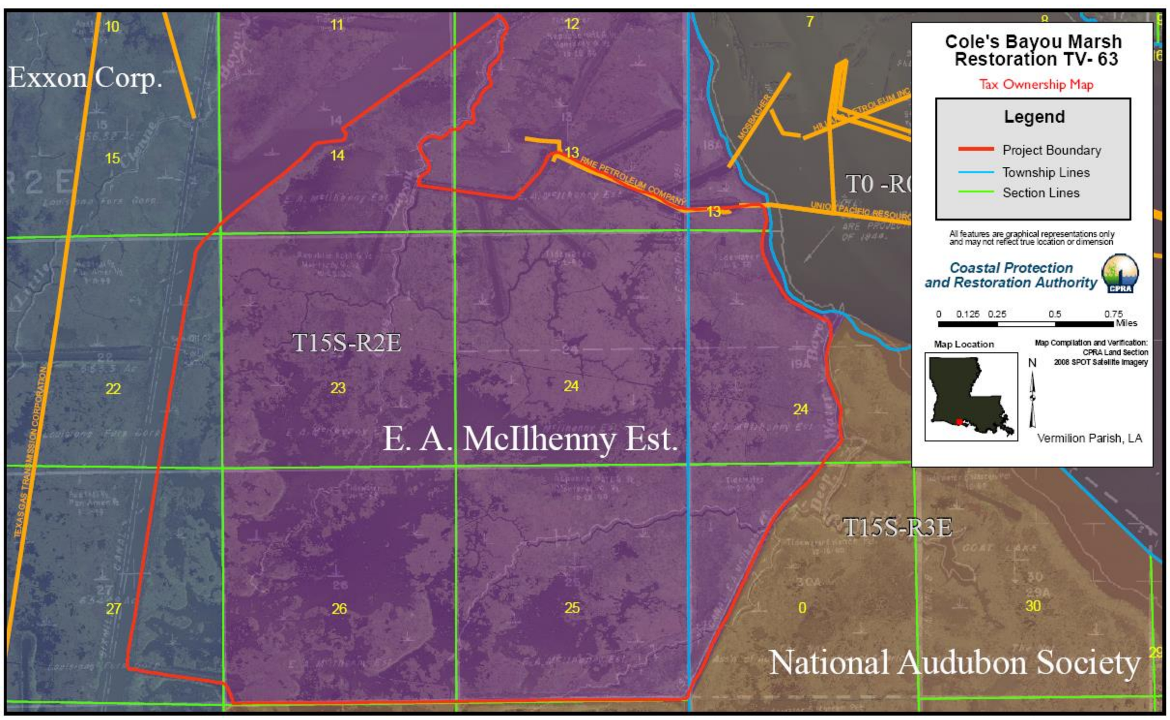


Figure 2: Tax Ownership map.

The NMFS contacted the State Historic Preservation Office (SHPO) regarding the TV-63 project requesting a determination of effect for any Area of Potential Effects (APE) that might be recorded within the project area, proposed borrow area, and access corridor. After a review of their files, their response was that no known historic properties will be affected by our proposed activities. This response from SHPO is included in Appendix D.

3.0 OYSTER LEASE ASSESSMENT

According to the CPRA Oyster Lease database, no active oyster leases are present in the proposed borrow area and the marsh fill areas. Little Vermilion Bay, however, is designated as an active oyster seed ground as shown in Figure 3. A CPRA Landrights Representative tasked T. Baker Smith to perform a biological survey along the proposed equipment access corridor, dredge pipeline alignment, and borrow area. No oysters were discovered within our proposed project features, and coordination with the Louisiana Department of Wildlife and Fisheries has begun.

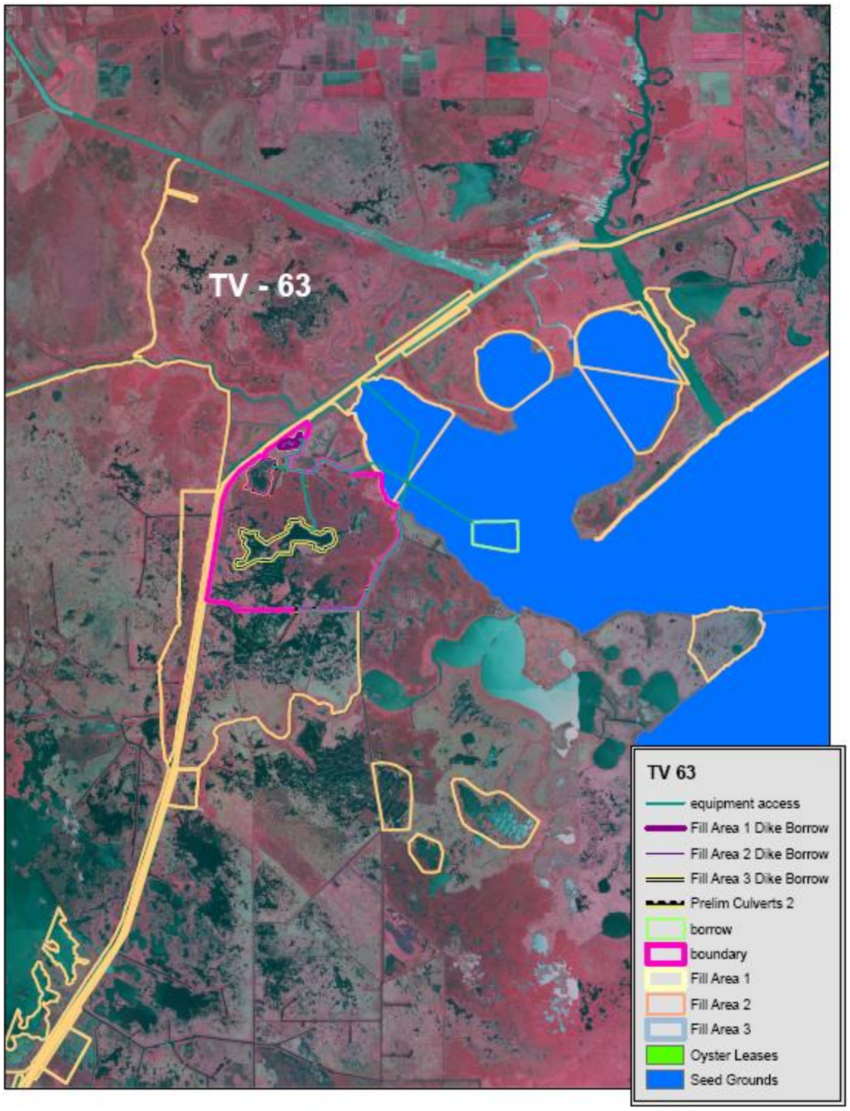


Figure 3: Active oyster leases and seed grounds in the TV-63 project area

4.0 EXISITING CONDITIONS

4.1 Tidal Datum

The tidal datum is a standard elevation defined by a certain phase of the tide and issued to measure local water levels. Establishment of the tidal datum for TV-63 occurred in the early stages of preliminary engineering since it pertains to many aspects of the project design including surveys, geotechnical analysis, and constructability. However, the primary objective for computing the tidal datum is to establish the target construction fill elevation that maximized the duration that the restored marsh will be at intertidal elevations throughout the 20-year project life.

A tidal datum is referenced to a fixed point known as a benchmark and is typically expressed in terms of mean high water (MHW), mean low water (MLW), and mean tidal levels (MTL) over the observed period of time. MHW is the average of all the high water heights observed over one tidal epoch. MLW is the average of all the low water elevations observed over one tidal epoch. MTL is the mean of the MHW and MLW for that time period. A normal tidal epoch lasts approximately 19 years; however, since this project is located near the Gulf of Mexico and has anomalous sea level changes, a modified tidal epoch of 5 years was used. In order to accurately estimate MHW and MLW elevations, a data set which has less than 5 years of data should be correlated to a gage which has data from a full modified tidal epoch using a technique known as the Range-Ratio method[10].

An internal gage (TV63-04) was set up to record the water levels within the project area on an hourly basis. The Coastwide Reference Monitoring System (CRMS) monitoring station CRMS2041 located at 29°45'59.04"N, 92°10'0.48"W was selected as the control station. The period of record used for the modified 5-year tidal epoch was July 17, 2008 to January 17, 2014. A detailed summary of the tidal datum calculations is shown in the Design Calculations Packet located in Appendix F. The results of the tidal datum determination for the TV-63 project area are as follows:

- MHW = 0.68 ft, NAVD88
- MLW = 0.48 ft, NAVD88
- MTL = 0.57 ft, NAVD88

Since the project area is semi-impounded, the tidal range found within the internal marshes is different from the ranges found in Little Vermilion Bay and different from the tidal ranges found in the oil field canals. The tidal range for the Little Vermilion Bay is as follows:

- MHW= 1.86 ft, NAVD88
- MLW= 1.15 ft, NAVD88
- MTL= 1.51 ft, NAVD88

The tidal range for the oil field canals found immediately adjacent to the earthen berm is as follows:

- MHW= 0.92 ft, NAVD88
- MLW= -0.12 ft, NAVD88
- MTL= 1.04 ft, NAVD88

The oil field canals are not directly connected to Little Vermilion Bay, which accounts for the difference in tidal range.

Because of the these tidal variances, an additional water level determination method such as percent inundation determination was used to find the acceptable water level range for determining the target marsh elevation.

4.2 Hydrologic Monitoring Stations

In order to monitor the project area conditions more closely, ENCOS was tasked to install six (6) hydrologic monitoring stations in various locations in and around the project area as shown in Figure 4. These stations collected water level data, salinity data, turbidity, and total suspended solids (TSS) data on an hourly basis for a six month period between April 2013 and October 2013. This data was then used to calibrate the ADH hydrodynamic model (discussed in Section 7.0) and was used to determine the appropriate tidal range for design.

Figure 4: Hydrologic Monitoring Station Locations

4.3 Percent Inundation Determination

The vertical positioning of marsh platforms and the frequency with which the marsh floods, strongly influence plant communities and marsh health[7, 11]. Historically, tidal range between mean high water (MHW) and mean low water (MLW) has been the accepted range for healthy marsh. This approach has worked well in tidal salt marshes where most of the water level variability is due to astronomical tides. Across Louisiana's coastal wetlands, however, non-tidal influences such as meteorological events, river discharge, and management regimes often have significantly more influence on water levels than astronomical tides. Therefore, we propose using percent inundation rather than tidal range as a proxy for marsh health. Percent inundation refers to the percentage of the year a certain elevation of land would be flooded based on the water levels found in that region. To illustrate the two approaches, Figure 5 shows both MHW and MLW and 10% and 65% inundation levels.

To determine percent inundation the TV63-04 gage was correlated to the CRMS2041 gage by the Direct Method[10]. A detailed summary of the percent inundation calculations is shown in the Design Calculations Packet located in Appendix F. The results of the percent inundation determination for TV-63 at TY0 and TY20 are shown in Table 1.

TY0	Elevation (ft, NAVD88) - % inundation for TY-0
10%	1.26
20%	0.96
30%	0.80
40%	0.68
50%	0.6
60%	0.50
65%	0.43
70%	0.42
80%	0.25
90%	-0.01

TY20	Elevation (ft, NAVD88) - % inundation for TY-20
10%	1.95
20%	1.65
30%	1.49
40%	1.37
50%	1.29
60%	1.19
65%	1.12
70%	1.11
80%	0.94
90%	0.68

Table 1: Percent inundation elevations.

Brackish marshes, like those in the TV-63 project area, are most productive when flooded between 10% and 65% of the time[8]. The project team utilized best professional judgment to identify target constructed marsh elevations that would maximize short term and long-term marsh function while taking into account relative sea-level rise (RSLR) (Figure 5).

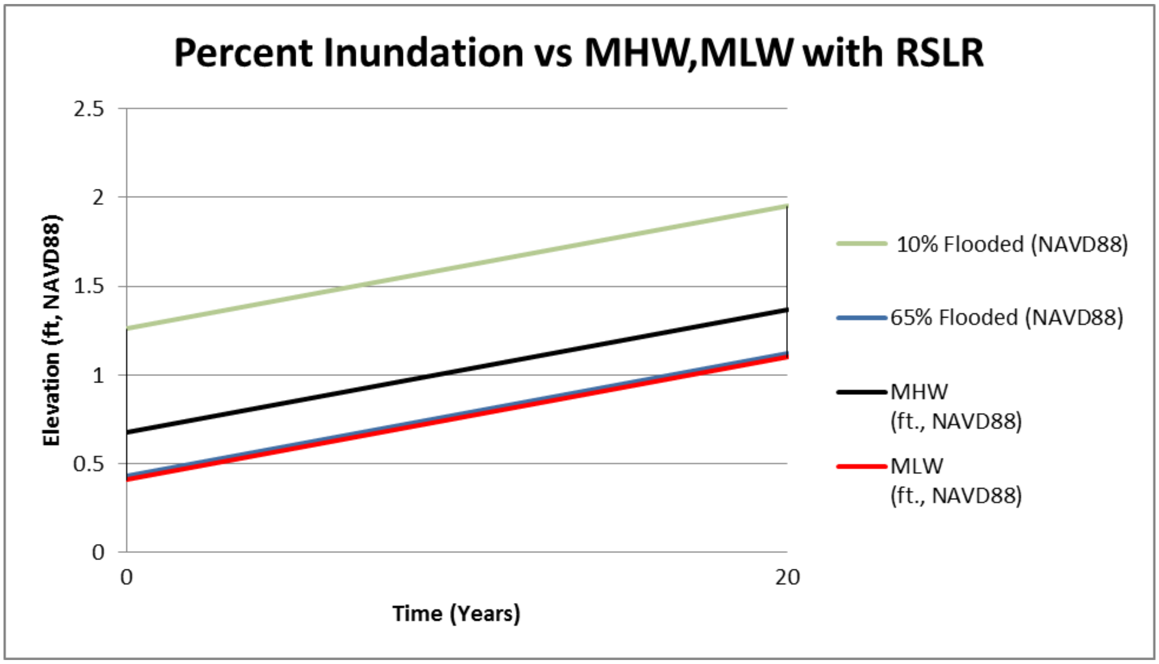


Figure 5: Percent inundation and MHW, MLW comparison.

Short-term accretion measurements collected at nearby CRMS Stations (0501, 0508, 0535, 2041) range from 1mm to 16mm per year. We expect accretion to at least partially offset the impact of RSLR on the relative vertical position of the marsh platform. However, because of spatial and temporal variability and uncertainty about extrapolating short-term accretion data over the project life, we are not representing it in our estimated settlement curves or RSLR calculations.

4.4 Relative Sea Level Rise

Since all projects within the CWPPRA program are built and evaluated based on a 20-year project life, they are expected to continue to perform the objectives mention in Section 1 throughout the design life. Therefore, to properly design the project to meet the 20-year goal, certain natural processes need to be assessed.

One process is Relative Seal Level Rise (RSLR). RSLR can be broken down into two components, Eustatic (or Global) Sea Level Rise and Subsidence; the latter of which will be described in Section 6.3. Sea Level Rise refers to a global change in water level. The value associated with Sea Level Rise is based on a global average rate of increase of water level that takes into account a number of variables such as thermal expansion, loss of glaciers and ice caps, runoff from thawing permafrost, to name a few. This means of measuring the seal level rise rate is expressed by the Intergovernmental Panel on Climate Change (IPCC). The latest IPCC evaluation (2007) has determined the global sea level rise to be 0.005576 feet/year[6].

To determine a most likely change in sea level over time, CPRA utilized its Planning Division to assist with calculating this value. The Planning Division attempted to bracket this rate by providing a lower and higher value to account for uncertainty. The range for possible relative sea-level rise by 2032 calculated is 0.5 ft - 0.9 ft[6].

5.0 SURVEYS

5.1 Topographic, Bathymetric and Magnetometer Surveys

Topographic, bathymetric, and magnetometer survey data was collected within the marsh creation fill areas, borrow area, equipment access corridor, and dredge pipeline alignment in order to facilitate the modeling of the project area and the design of the marsh creation fill areas, the water control structures, and the borrow areas. The majority of the design survey effort was performed from April 2013 to June 2013 by HydroTerra, Inc., and additional surveys were performed from October 2014 to November 2014. All horizontal coordinates are referenced to Louisiana State Plane Coordinate System, North American Datum of 1983 (NAD 83). All elevations are referenced to North American Vertical Datum of 1988 (NAVD 88) GEOID12A[2].

5.2 Horizontal and Vertical Control

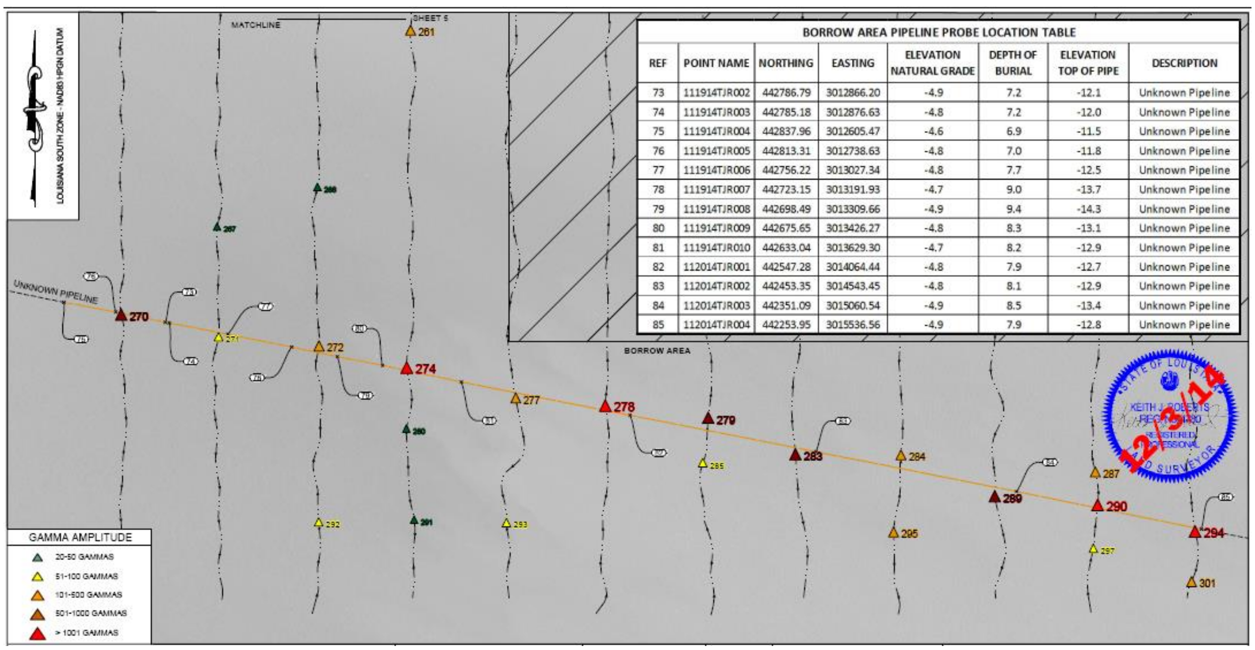
One National Geodetic Survey (NGS) primary monument and two permanent secondary monuments (TV12-SM-01 and CRMSTV-SM-06) exist in the vicinity of Cole's Bayou. NGS monument "57 V 96 LADH" is located at the intersection of LA Hwy 333 and Oyster Lane in Intracoastal City, Louisiana at the coordinates 29°47'4.18"N, 92°9'24.37"W. TV12-SM-01 is located north of Vermilion Bay set in North Buck Point Oil and Gas field, southerly Freshwater Bayou at coordinates 29°45'13.192033" N, 92°12'06.075020" W. CRMSTV-SM-06 is located 0.88 miles southeast of the McKinely Camp on Belle Isle Bayou at coordinates 29°39'48.20505" N, 92°13'10.59914"W. These two secondary monuments were tied to and used to supplement the primary monument and were used as horizontal and vertical controls for the marsh creation fill area surveys, access survey, and perimeter survey. Observations lasting four hours on different days and at different times were conducted to ensure different satellite geometry[4]. The data sheets for these monuments are located in Appendix A.

5.3 Marsh Creation Fill Area Surveys

Survey transects were taken every 250 feet in a grid format, as shown in Appendix B. Transects were taken over open water areas, broken marsh, and across pipeline canals within the proposed project area. Position, elevation, and water depth were recorded every 50 feet along each transect or where elevation changes were greater than 0.5 feet. Topographic and bathymetric survey methods were used as applicable to obtain all transects and were consistent with CPRA Standards. The topographic portions were merged with the bathymetric portions at the land/water interface and were separated by no more than 50 feet. Side shots were taken as necessary to pick up variations in topographic features (highs and lows) such as trenasses, meandering channels, broken marsh areas, or any other existing features such as pipelines, well heads, and warning signs which may affect project design implementation. The use of a fixed height aluminum rod (8' or 10' in length) with a 6" diameter metal plate as the base of the rod was used to prevent the rod from sinking when topographic data was collected.

A magnetometer survey was taken in each of the marsh creation fill areas as well as the proposed pipeline access corridors (shown in Appendix B). The survey was used to identify any potential existing pipelines and other obstructions within the project area. A Geometrics 882 cesium magnetometer was utilized and correlated to a position with RTK GPS using the Hypack Navigation Software package. For each magnetic finding, a closed loop path was run with the magnetometer. The path completely enclosed the original finding location, while maintaining a distance of approximately 25 feet from that location.

The magnetometer survey verified the existence of two pipelines within the project area. The first, a 10-inch diameter Acadian line positioned between the two northern cells, across Cole's Bayou, and intersects with the equipment access corridor. This pipeline has a depth of cover of approximately 5 feet on average on land and about 10 feet on average in Little Vermilion Bay. The second pipeline shown is an abandoned pipeline of unknown diameter that bisects the project area. Its depth of cover is on average approximately 5 feet on land and approximately 7.5 feet in Little Vermilion Bay as shown in Figure 6. The magnetometer survey lines and locations of anomalies and intensities are shown on the HydroTerra magnetometer survey drawings in Appendix B.



BORROW AREA PIPELINE PROBE LOCATION TABLE							
REF	POINT NAME	NORTHING	EASTING	ELEVATION NATURAL GRADE	DEPTH OF BURIAL	ELEVATION TOP OF PIPE	DESCRIPTION
73	111914TJR002	442786.79	3012866.20	-4.9	7.2	-12.1	Unknown Pipeline
74	111914TJR003	442785.18	3012876.63	-4.8	7.2	-12.0	Unknown Pipeline
75	111914TJR004	442837.96	3012605.47	-4.6	6.9	-11.5	Unknown Pipeline
76	111914TJR005	442813.31	3012738.63	-4.8	7.0	-11.8	Unknown Pipeline
77	111914TJR006	442756.22	3013027.34	-4.8	7.7	-12.5	Unknown Pipeline
78	111914TJR007	442723.15	3013191.93	-4.7	9.0	-13.7	Unknown Pipeline
79	111914TJR008	442698.49	3013309.66	-4.9	9.4	-14.3	Unknown Pipeline
80	111914TJR009	442675.65	3013426.27	-4.8	8.3	-13.1	Unknown Pipeline
81	111914TJR010	442633.04	3013629.30	-4.7	8.2	-12.9	Unknown Pipeline
82	112014TJR001	442547.28	3014064.44	-4.8	7.9	-12.7	Unknown Pipeline
83	112014TJR002	442453.35	3014543.45	-4.8	8.1	-12.9	Unknown Pipeline
84	112014TJR003	442351.09	3015060.54	-4.9	8.5	-13.4	Unknown Pipeline
85	112014TJR004	442253.95	3015536.56	-4.9	7.9	-12.8	Unknown Pipeline

Figure 6: Pipeline probe depths near proposed borrow area.

5.4 Healthy Marsh Elevation Survey

Elevations from points shown in Appendix B that appeared to have healthy marsh were utilized to determine an average elevation of healthy marsh. Table 3 shows the results of the average healthy marsh survey. According to this survey, healthy marsh elevation should be 0.75 ft. However, since the project area is semi-impounded, what is considered healthy within the existing dike surrounding the project area is lower than what is considered healthy outside of the dike. Healthy elevations in the marshes surrounding the project area range from 0.8 to 2.2 ft based on survey data taken during the installation of nearby CRMS stations. Survey reports for the surrounding CRMS stations are located in Appendix A.

Location	Elevation
M-1	0.88
M-2	0.77
M-3	0.71
M-4	0.60
M-5	0.80
Average	**0.75**

Table 2: Average healthy marsh elevation survey results.

5.5 Borrow Area Survey

Survey transects were taken every 250 feet in the proposed borrow area. Position, elevation, and water depth were recorded every 50 feet along each transect or where elevation changes were greater than 0.5 feet. Bathymetric survey methods consistent with CPRA Standards were used to obtain all transects[2].

In addition to a bathymetric survey, a magnetometer survey was performed along the same transects as the bathymetric survey. This survey identified any pipelines, well heads, or any other obstructions within the borrow area. Similar equipment that was used on the marsh fill area magnetometer survey was utilized also in the proposed borrow area.

The magnetometer survey verified the existence of one pipeline that was the continuation of the pipeline found in the center of the project area, and affected the southwest corner of the proposed borrow area. According to the CPRA Landrights representative, the pipeline is an abandoned pipeline of unknown diameter, and depth of cover was found to be approximately 7.5 feet as shown in Figure 6. This was the only significant anomaly found within the proposed borrow area. A 100 foot buffer between the alignment of the pipeline and the southern extent of the borrow area has been placed to ensure the dredge can operate safely.

5.6 Equipment Access Corridor and Dredge Pipeline Alignment Surveys

An additional bathymetric and magnetometer survey was performed from Freshwater Bayou to the McIlhenny Canal and from the offshore borrow area. The purpose of this survey was to identify alternate access routes for the dredge pipeline and marine construction equipment.

A centerline profile was taken along the equipment access and pipeline alignments respectively. 200 feet long and perpendicular transects were taken along the alignments every 1000 feet. Position, elevation, and water depths were recorded every 50 feet along each transect and centerline profile or where elevation changes were greater than 0.5 feet. Bathymetric and topographic survey methods were used where applicable to obtain all transects along the equipment access corridor and the dredge pipeline alignment. Bathymetric and topographic portions were merged at the land/water interface and were separated by no more than 50 feet.

A magnetometer survey was taken along the alignments and utilized similar methods seen in the borrow area magnetometer survey. The survey verified the existence of two pipelines. The first intersected the equipment access corridor and was a continuation of the 10 inch Acadian line that was present in the project area. This pipeline has a depth of cover of approximately 10 feet. The second pipeline also intersected the equipment access corridor and was a small 2-3 inch Acadian flow line. This pipeline had depth of cover of approximately 5 feet. According to an Acadian representative, the flow line was removed in April 2015.

6.0 GEOTECHNICAL ENGINEERING ANALYSIS

In order to determine the suitability and physical characteristics of the soils in the TV-63 project area, a geotechnical subsurface investigation and geotechnical engineering analysis was conducted by Ardaman & Associates, Inc. Ardaman & Associates, Inc. was tasked to collect soil borings, perform laboratory tests to determine soil characteristics, perform global slope stability analysis of the proposed earthen containment dikes, estimate the total settlement of the proposed earthen containment dikes and marsh creation fill areas, determine an adequate cut-to-fill ratio for the dredge and fill operations, and evaluate soil strength conditions at the water control structure locations.

6.1 Soils Investigation

Soil conditions were evaluated in the marsh creation fill areas and the water control structure areas by advancing twenty (20) soil borings to depths ranging from approximately 20 to 80 feet below existing. Six (6) additional soil borings were advanced to an approximate depth of 20 feet below mudline within the confines of the proposed borrow area. The approximate soil boring locations are shown in Figure 7.

The soil borings were performed in 0 to 5 feet of water. Samples were collected continuously in the upper 20-feet of the soil and on 5-foot centers thereafter to boring completion depths. The soil borings were completed between October and November 2013 using an airboat-mounted, rotary-type drilling rig. Soil strength, unit weight, and index properties observed during drilling and laboratory test results are located on the soil boring logs in Appendix C[1].

Shelby tube samples were tested for miniature vane shear strength and removed from their tubes. Laboratory tests included soil compressive strength, moisture content, organic content, grain size analysis, specific gravity, consolidation with rebound, and Atterberg limits.

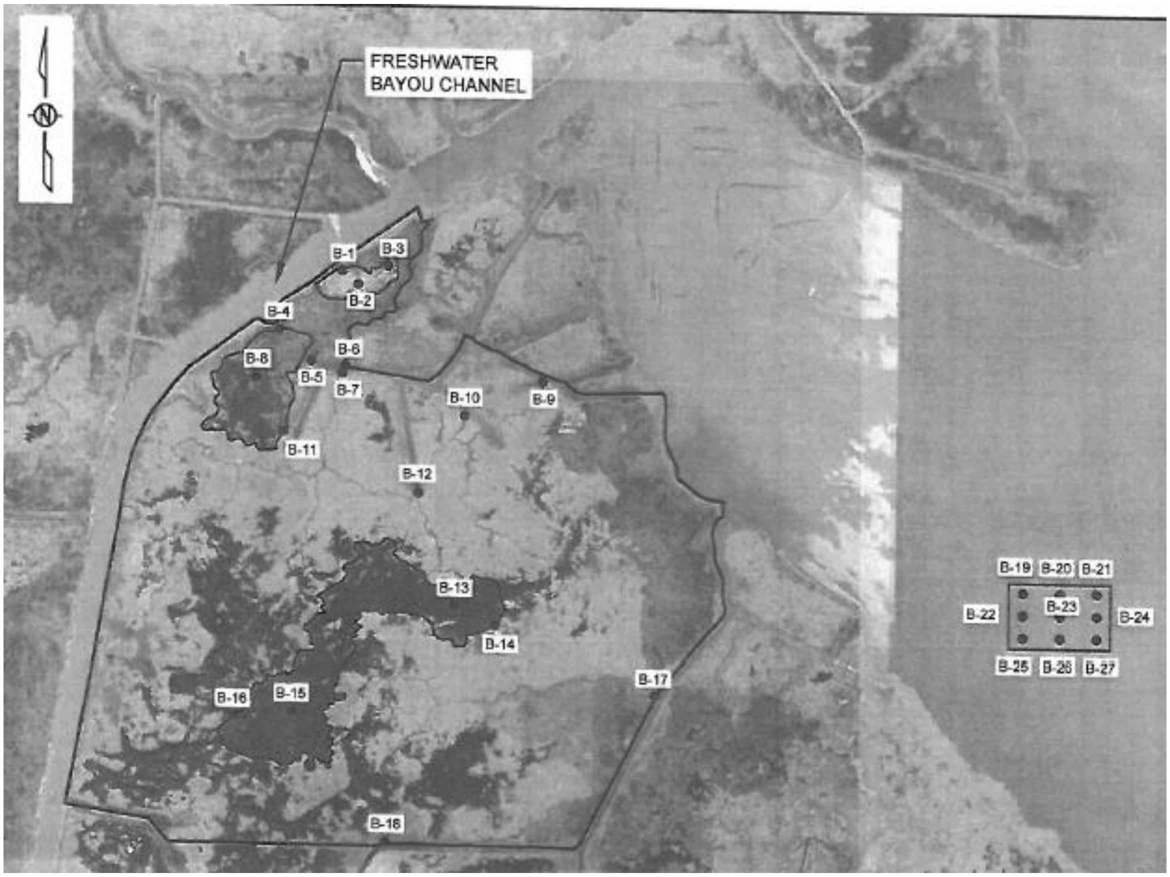


Figure 7: Soil Borings Locations

6.2 General Geologic Evaluation

Subsurface conditions do not vary widely across the project area. Generally there is very soft to soft clay and silty clay with organics to depths ranging from about 10-15 feet below the mudline. Interface depths vary significantly from boring to boring. These soft surficial soils are underlain by medium to stiff clay or silty clay soil.

6.3 Subsidence

The other natural process that needs to be considered in design of the project to achieve the project goals over the 20-year project life is subsidence. Subsidence is defined as the rate of local vertical land movement and is measured locally. Causes of subsidence include natural processes such as tectonics (faulting) and Holocene sediment compaction, as well as man-related causes such as removal of subsurface fluids. There continues to be much discussion on the dominating cause of subsidence in Louisiana.

To calculate subsidence, CPRA's Planning Division used the ranges of subsidence values shown in Figure 8. The figure was created using some of the lowest and highest subsidence rates found in those areas by researchers. The Cole's Bayou area has a wide range of subsidence rates (1-15mm/yr) seen in coastal Louisiana[5, 6]. By combining the range for possible relative sea-level rise by 2032 calculated by CPRA's Planning Division (0.5 ft- 0.9 ft) discussed in Section 4.4, this equates to a combined subsidence and sea level rise of approximately 5 to 10 inches over the 20-year design life of this project as shown in Figure 3. This information was included in the marsh creation fill settlement curves to predict water levels at year 20 as shown in Figures 10 and 11 (Section 6.6).

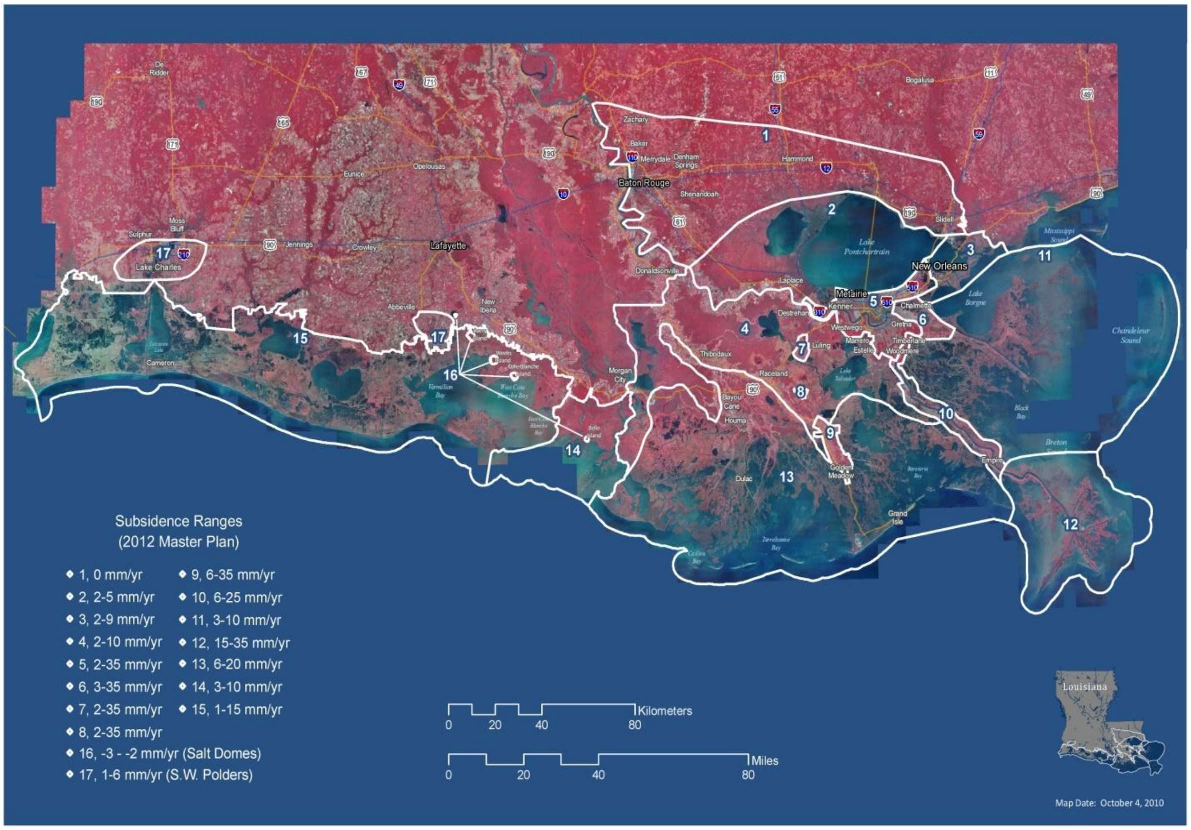


Figure 8: Map of Projected Subsidence Ranges for South Louisiana Generated by the Subsidence Advisory Panel for the Louisiana CPRA Master Plan 2012

6.4 Earthen Containment Dike Slope Stability Analysis

Slope stability analyses were performed on the proposed earthen containment dikes at different elevations and geometries. The slope stability of the earthen containment dike has two types of driving forces: (1) the forces induced by the soil weight, and (2) any seepage forces which tend to cause the soil to slide. In response to these driving forces, the subsurface soils have a resistant force in the form of shear strength, which attempts to keep the slope from sliding. Both the driving forces and the resisting forces are dependent on the geometry of the situation: the "Failure Surface". Ardaman & Associates, Inc. performed a stability analysis that computes factors of safety, against potential failure based on limit equilibrium theory.

Table 4 shows the results of slope stability calculations for the earthen containment dikes at elevations that would allow at least one foot of freeboard during the filling of the marsh creation cells. A factor of safety of 1.5 was determined by Ardaman and Associates, Inc. to be acceptable for slope stability purposes. Since all factors of safety were above 1.5, no geo-textile reinforcement is required.

Marsh Area	Estimated Berm Crest El. (ft. NAVD88)	Borrow Excavation Offset (ft.)	Berm Side Slope	Factors of Safety		
				Circular Arc In Berm Slope	Circular Arc Bearing Capacity	Global Sliding Toward Borrow Pit
1	+3.0	20	4H:1V	2.02	2.74	2.66
	+4.0			1.61	2.22	2.18
2	+3.0	20	4H:1V	3.97	4.89	3.31
	+4.0			2.71	2.86	2.62
3	+3.0	20	4H:1V	2.02	3.10	2.65
	+4.0			1.61	2.38	2.08

Table 3: Earthen Containment Dike Slope Stability Results.

6.5 Earthen Containment Dike Settlement Analysis

Settlement of the foundation soils beneath the earthen containment dikes were computed based on the dike geometries determined from the slope stability analyses and the soil properties of the underlying soils. Reducing the crown elevation and width will decrease the amount of settlement under the earthen containment dikes. Settlement factors include regional subsidence, self-weight consolidation, and elastic settlement of the in situ soils. Self-weight consolidation is dependent on several factors, including organic content, natural moisture content, and construction methodology. Elastic settlement of the in situ soils will occur quickly and will likely result in an increase in the quantity of fill required to reach the design construction elevation.

Settlement for the containment dikes was performed using elevations ranging from +3.0 to +4.0 feet NAVD 88 in 0.5 foot increments. The actual design elevations ranged from +3.0 to +3.5 feet NAVD88 and are shown in Figures 21 and 22 in Section 8.2 Earthen Containment Dike Design.

6.6 Marsh Creation Settlement Analysis

A settlement analysis was performed to determine the construction marsh fill elevation of the marsh creation fill areas and the total volume of fill material. The final elevation of the marsh creation (at year twenty) is governed by two forms of settlement: (1) the settlement of the underlying soils in the marsh creation areas caused by the loading exerted by the placement of the dredged fill material, and (2) the self-weight consolidation of the dredged material (See Figure 9). Data from low pressure consolidation tests were used to estimate the time-rate of settlement of the underlying soils of the marsh creation fill areas. Self-weight consolidation tests were performed on a composite sample from the borrow area material (borings B-19 through B-24) to estimate the self-weight consolidation of the dredged fill material.

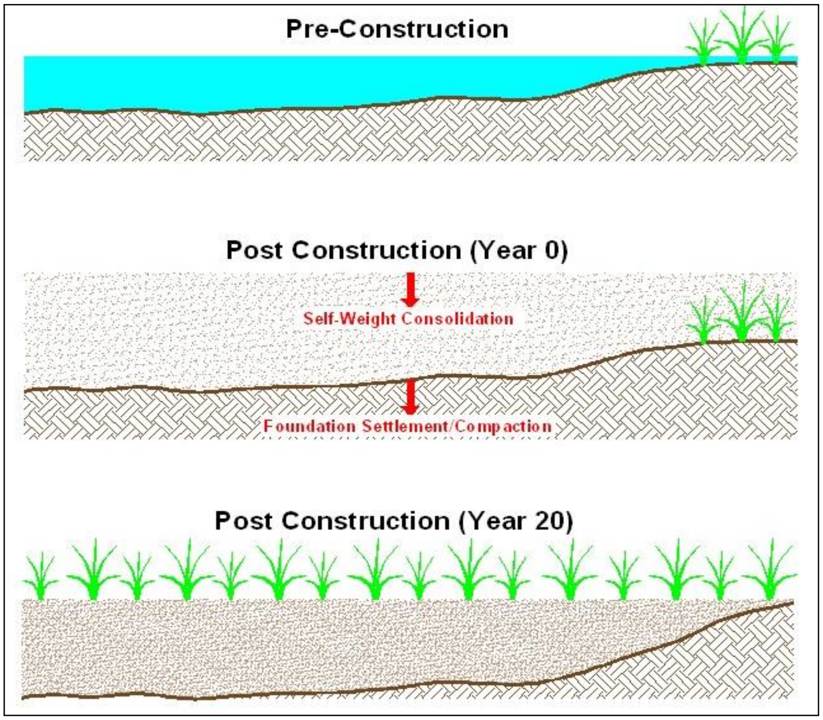
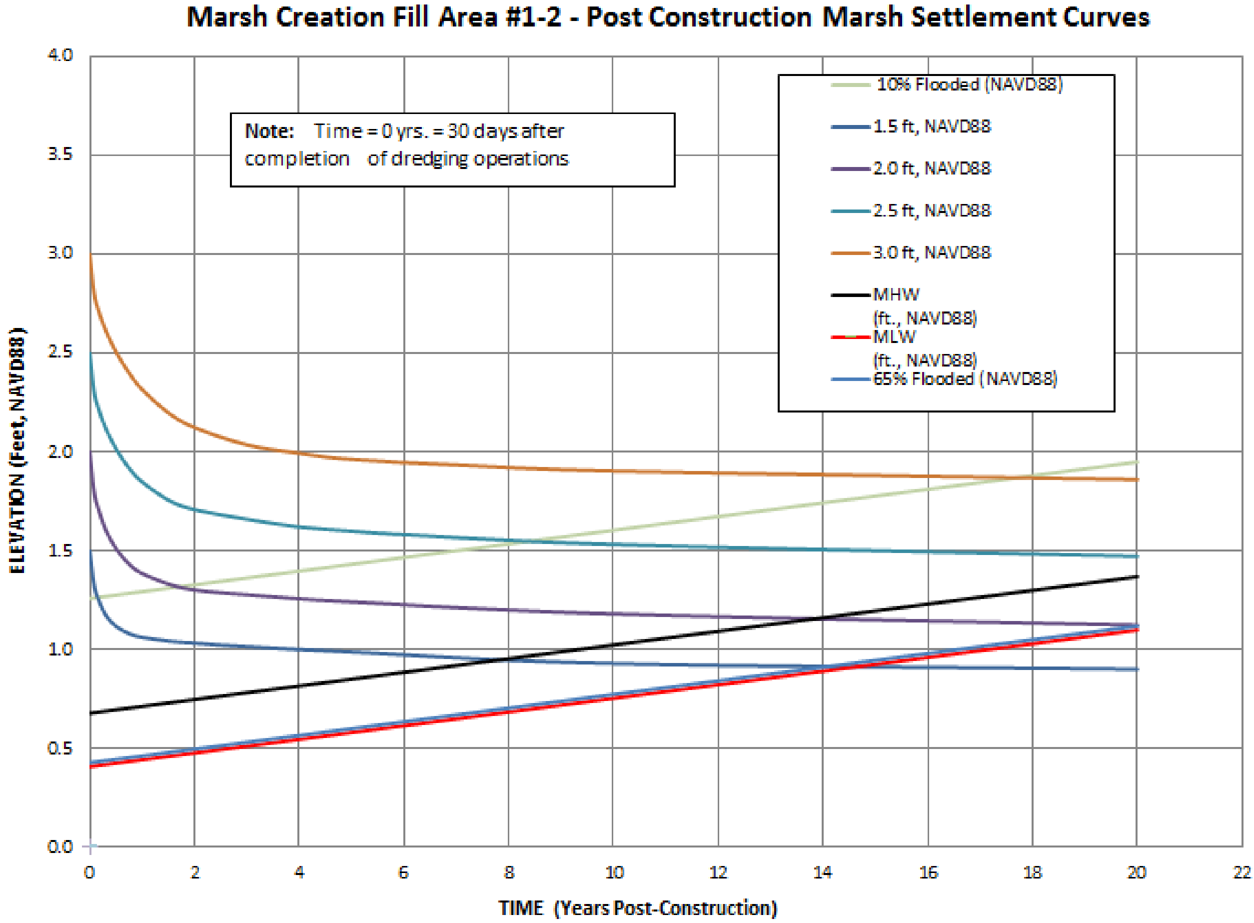


Figure 9: Marsh Creation Settlement

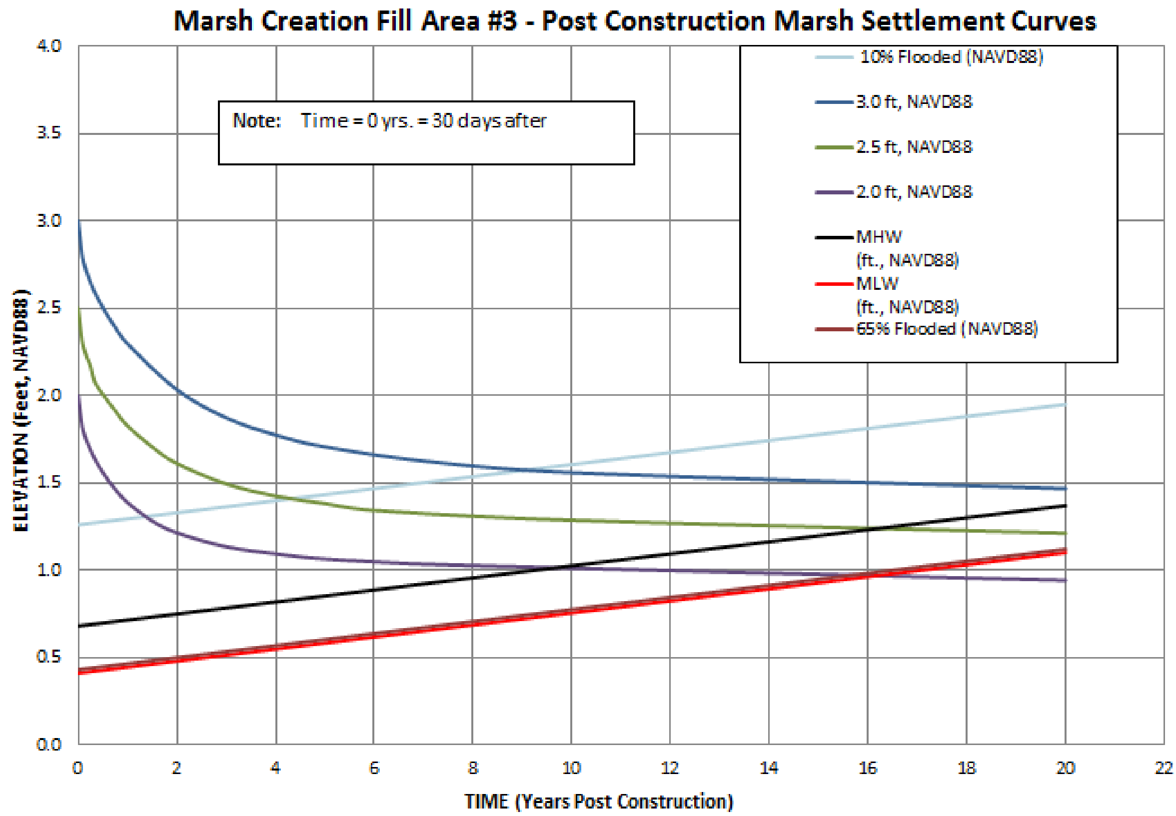
Settlement curves were developed in 0.5ft increments for proposed construction marsh fill elevations ranging from 1.5 feet to 3.0 feet NAVD 88. These settlement curves show the changes in elevation over the 20-year design life of the project and were used to compare different marsh fill elevations.

The estimated total settlement for Marsh Creation Fill Areas 1 and 2 is shown in Figure 10, and the estimated total settlement for Marsh Creation Fill Area 3 is shown in Figure 11. There is very little settlement after 6 months, which is favorable for the project over the 20-year project life. The elevation of each marsh creation fill area is determined based on the settlement curves associated with that area.

To determine the final constructed marsh fill elevation that would yield the most productive marsh at the end of the 20-year project life, water levels from within the project area, water levels from outside of the project area, water levels from inside the project area, and subsidence and sea level rise were taken into account. Accretion was not taken into account due to the uncertainty in calculating short-term accretion rates.



Figures 10: Estimated Total Settlement Curves for marsh creation fill sites 1 and 2 overlaid on the 10% inundated, 65% inundated, MHW, and MLW lines, including RSLR.



Figures 11: Estimated Total Settlement Curves for marsh creation fill site 3 overlaid on the 10% inundated, 65% inundated, MHW, and MLW lines including RSLR.

Since the project area is semi-impounded, interior marshes are not exposed to the tidal influences present in Little Vermilion Bay like the surrounding marshes. This is apparent when looking at the Healthy Marsh Elevation Survey results discussed in Section 3.4. Therefore, the final marsh elevation for TV-63 should fall somewhere in the range of what is considered healthy within the project area and what is considered healthy in the surrounding marshes.

The ideal final marsh elevation would fall around the 50% inundated mark at the end of the 20 year project life and would spend the majority of the project life within the functional brackish marsh range (10%-65% inundated). For this project, +1.3 ft, NAVD88 was determined to best fit the criteria for final target marsh elevation.

6.7 Cut to Fill Ratio Recommendations

A cut to fill ratio was determined by Ardaman and Associates in order to account for losses due to dredging, containment, and dewatering. A cut to fill ratio of 1.5 will be applied for all hydraulically dredged marsh fill sediment. Mechanical dredging of the containment dikes has generally yielded a cut to fill ratio approximately between 1.2 and 1.6. For this project a cut to fill of 1.3 will be used for mechanical dredging of the containment dikes.

7.0 HYDRODYNAMIC MODELING

7.1 Model Setup

Dynamic Solutions was tasked to model the hydrodynamics within the project area and help to determine the best course of action to reconnect the system with the surrounding marshes. The Adaptive Hydraulics Model (ADH) was chosen to track changes in water movement and changes in salinity. The ADH model was recommended because of its ability to handle complex domains and simulate flow through hydraulic structures[3]. The model was then calibrated using data collected by the ENCOS monitoring stations. A copy of Dynamic Solutions' final report can be found in Appendix G.

7.2 Model Runs

Three scenarios were evaluated to determine the best course of action to reconnect the project area to the surrounding marshes. An existing conditions model run was performed to get an idea of the conditions at the present time. The run showed the majority of the project area being inundated between 50 and 100% of the time. Flow through the project area was limited to the breaches present throughout the northern boundary, and little to no water was exiting the system to the south.

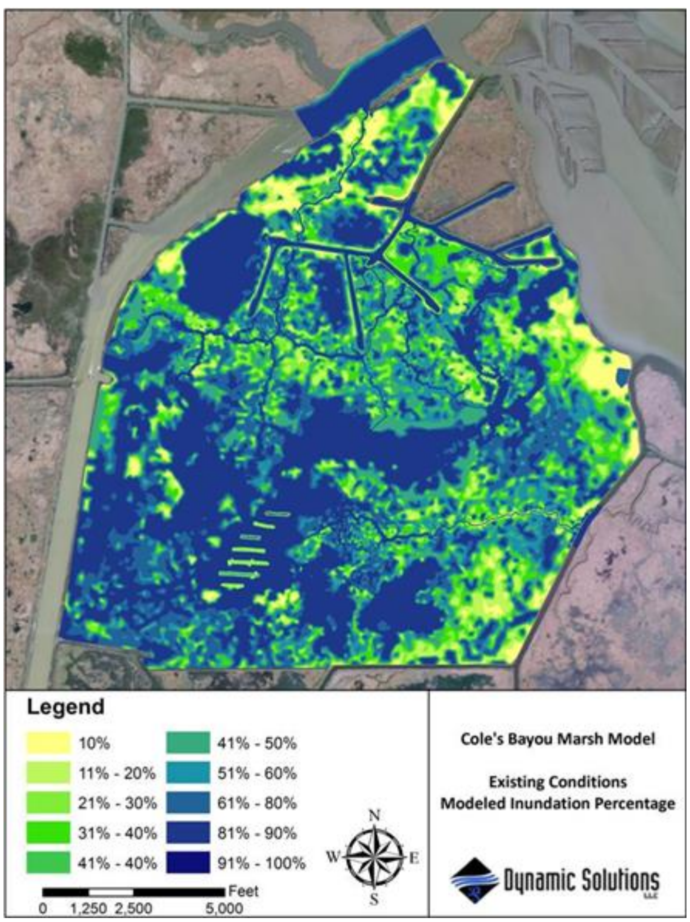


Figure 12: Existing conditions model run.

Scenario	Features	Flow In (cfs)	Flow Out (cfs)	Net Flow Out of Marsh(cfs)	Average Water Level (ft)
Existing	-	19.8	23.9	4.1	0.96
1	Marsh Fill at +1.3ft, NAVD88	15.9	19.6	3.7	0.99
2	Marsh Fill at +1.3ft, NAVD88 Conveyance Channel around MC3 48in Culverts (Invert=0.0ft)	6.2	10.6	4.4	1.22
3	Marsh Fill at +1.3ft, NAVD88 Conveyance Channel around MC3 48in Culverts (Invert=-2.0ft)	40.5	43.8	3.3	1.02

Table 4: Summary of model runs performed.

7.2.1 Scenario 1-Marsh Creation Only

Scenario 1 looked at the hydrodynamic response of the system to adding the three marsh creation areas. In order to determine how the project area will act at the end of the 20-year project life, the marsh elevation was set to 1.3 ft NAVD88. Flow through the area was reduced in all areas except for the oil field canals. With the introduction of the marsh creation areas, water was no longer able to flow to the southern part of the project area. Since there was no overall increase in the flow, however, there was no significant reduction in inundation throughout the project area with the exception of the new marsh creation areas as shown by Figure 13.

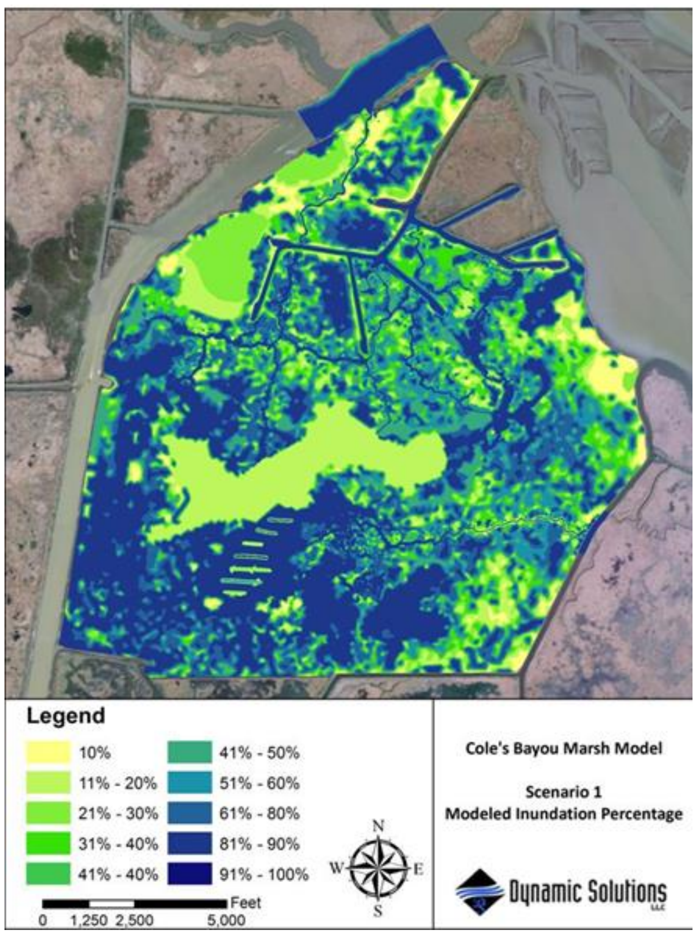


Figure 13: Scenario 1 percent inundation.

7.2.2 Scenario 2-Marsh Creation and Water Control Structures (Invert=0.0')

Scenario 2 simulated the response of the system to adding the three marsh creation areas, placing a borrow channel around the outside of the largest fill cell, and adding eight (8) inflow water control structures and two (2) outflow water control structures. The borrow channel around the largest marsh creation area served to reconnect the channels that were cut off after the marsh creation was placed to allow for better flow to the southern areas. All water control structures in the model were 48 inch diameter by 25 ft long one-way flap gated culverts and had an invert of 0.0 ft, NAVD88. The eight northern water control structures allow water to flow into the project area, and the two southern water control structures allow water to flow out of the project area into the surrounding marshes. In this scenario water flowed into the system more but wasn't able to leave the system resulting in larger areas being inundated for longer periods of time as shown in Figure 14.

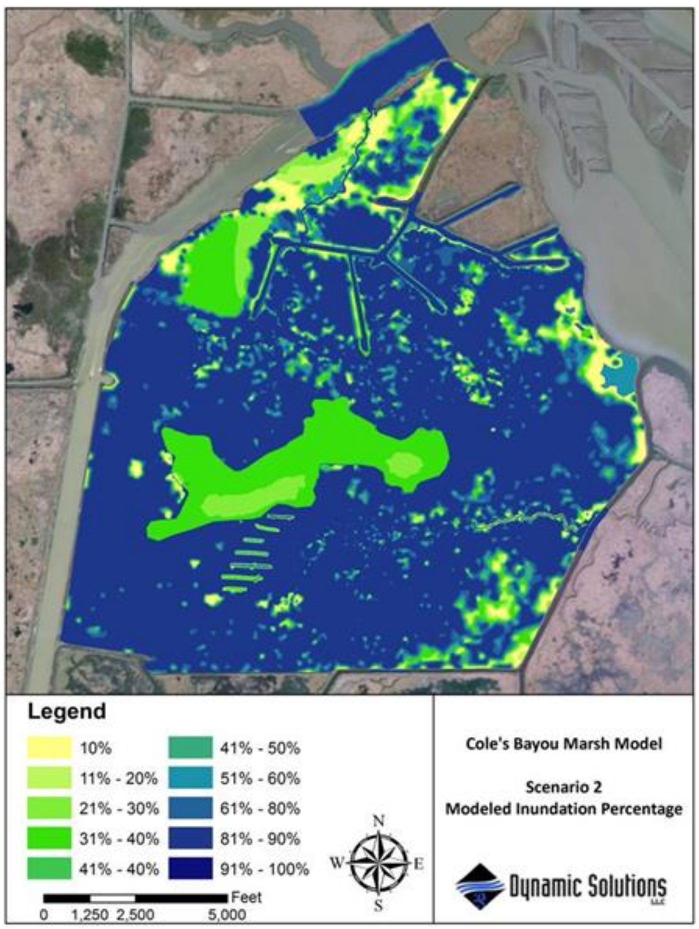


Figure 14: Scenario 2 percent inundation.

7.2.3 Scenario 3- Marsh Creation and Water Control Structures (Invert=-2.0')

Scenario 3 simulated the response of the system to adding the three marsh creation areas, placing a borrow channel around the outside of the largest fill cell, and adding eight (8) inflow and eight (8) outflow water control structures. This scenario differs from Scenario 2 by adding six more outflow water control structures and by dropping the inverts for all of the water control structures to -2.0' NAVD88. Water control structure dimensions and specifications were the same between scenarios 2 and 3. Flow throughout the system was increased from Scenario 2 and allowed for lesser inundation times throughout the project area as shown in Figure 17. The combination of increasing the number of outflow structures and setting the invert at a -2.0' allowed for better ingress and egress of water throughout the system.

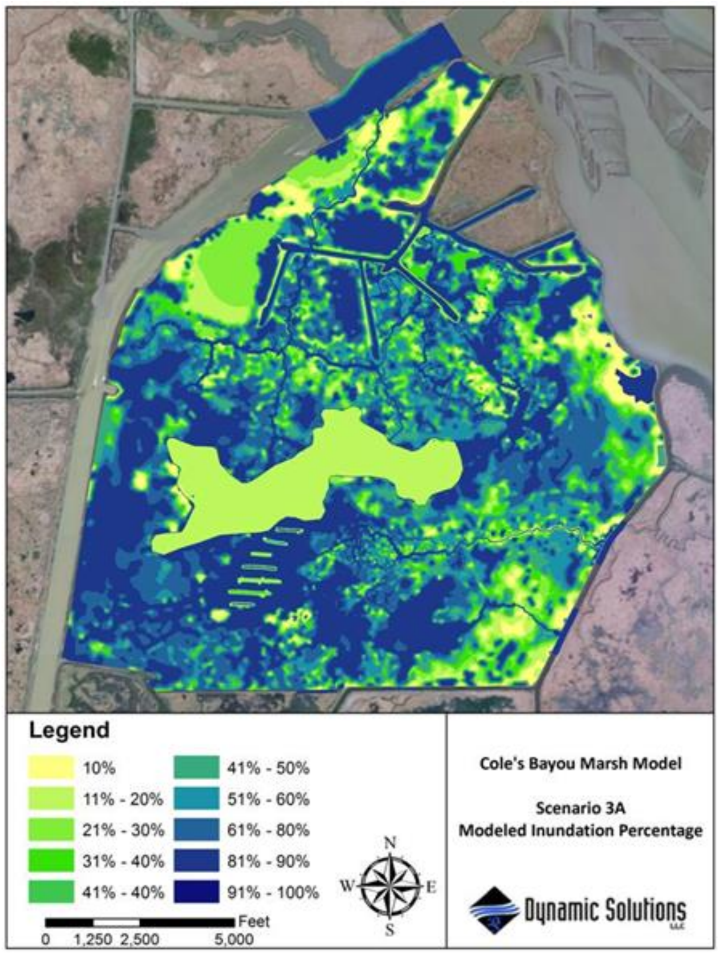


Figure 15: Scenario 3 percent inundation.

8.0 MARSH CREATION DESIGN

The project proposes to create marsh by dredging material from a borrow site located in Little Vermilion Bay for placement into the designated marsh creation fill areas shown in Figure 16 and the Preliminary Design Drawings located in Appendix E. The marsh creation design was broken into four (4) components: the marsh creation fill areas, the earthen containment dikes, the dredge borrow area, and the equipment access corridor. The design of each component is discussed in the sections below.

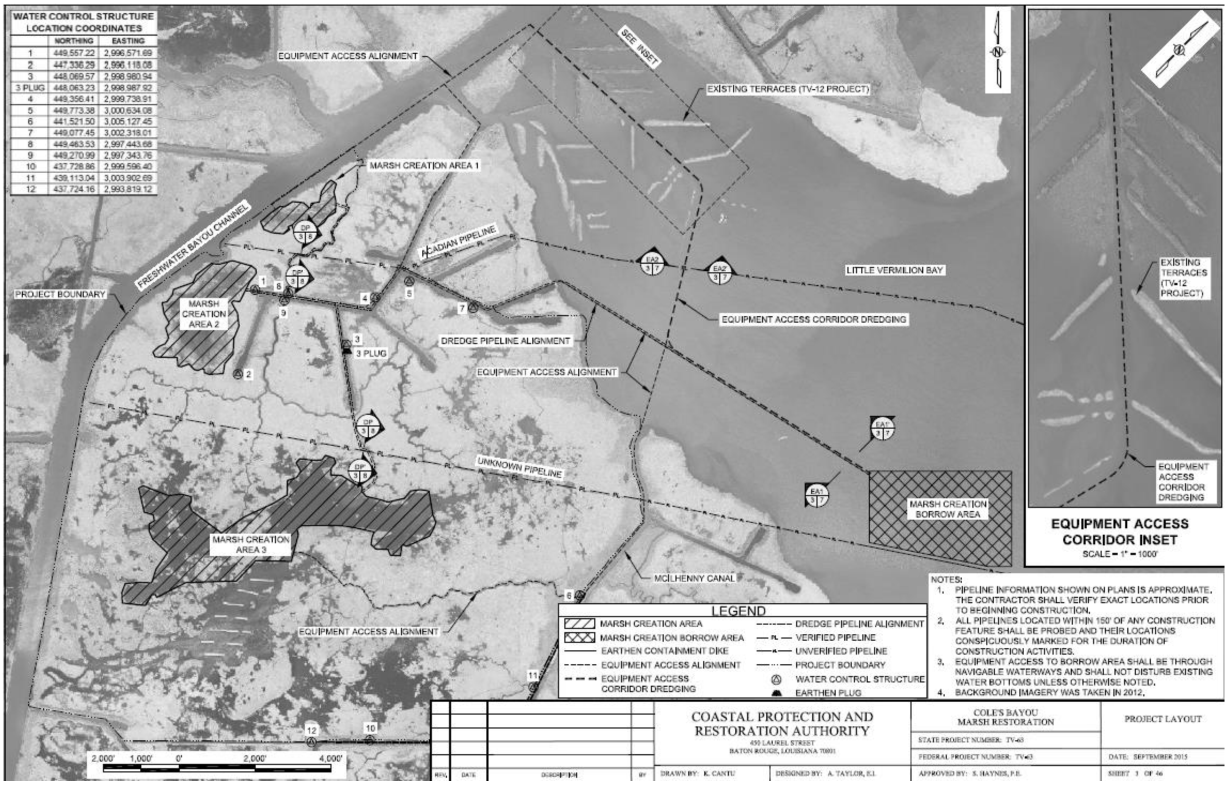


Figure 16: Plan views of the project design features.

8.1 Marsh Creation Fill Area Design

The primary goals of the marsh creation fill area features are to address the land loss in this area. These goals governed the configuration of the marsh creation fill areas. The main design component of TV-63 involves the calculation of the marsh fill volumes. Before this could be accomplished, a constructed marsh fill elevation had to be determined. This elevation was governed by several factors including the final target marsh elevation considering healthy marsh elevations obtained, percent inundation, the physical properties of the borrow material, and the bearing capacity of the foundation soils in each marsh creation area.

Determination of the construction marsh fill elevation is based on consideration of the average marsh elevation over the life of the project with respect to intended functioning of the marsh from both a habitat perspective and meeting the project goals and objectives. One element of the marsh design is to maximize the time period that the marsh platform has an elevation within the functional brackish marsh inundation range (10%-65% inundated) and maximize the time period spent in the range that most closely correlates to MHW and MLW (40%-70% inundated). Over the 20-year project life, and with a relative sea level rise rate of 0.005576 feet/year (as discussed in Section4.4), the 40% to 70% inundation range is expected to rise from +0.42 feet to +0.68 feet, NAVD88 and from +1.11 feet to +1.37 feet, NAVD88, respectively. As discussed in Section 6.6, the final target fill elevation is +1.3 ft, NAVD88. To achieve the desired final elevation, the marsh platform will initially have to be pumped to a constructed marsh fill elevation outside of the functional brackish marsh range (10%-65% inundated) and settle into the range over the design life.

For Marsh Creation Areas 1&2, the two northernmost marsh creation cells, an initial constructed marsh fill elevation of +2.0 feet will be sufficient to reach the final target marsh elevation. For Marsh Creation Area 3, an initial constructed marsh fill elevation of +2.5 feet will be sufficient to reach the final target marsh elevation.

After determining the constructed marsh fill elevations, the total volume of each marsh creation fill area is calculated by using AutoCAD Civil software. The software creates a 3-Dimensional surface based on XYZ coordinate data from the survey cross-sections. This surface is known as a Triangulated Irregular Network (TIN). The TIN model represents a surface as a set of contiguous, non-overlapping triangles. Both a TIN surface containing the 2013 survey data from HydroTerra and a flat TIN surface at the creation construction elevation was generated by AutoCAD. AutoCAD then uses the XYZ differences of each surface to calculate the volume of each marsh creation area. Since the containment borrow must be refilled in cells 1 and 2, the volume required to build containment dikes plus a cut-to-fill ratio of 1.3 for the dikes is then added to the volume required to fill the marsh creation areas. The cut-to-fill ratio of 1.5 is then applied, resulting in a final estimate of volumes for each marsh creation area. Table 6 summarizes the fill volumes for each marsh creation area within the TV-63 project.

Marsh Creation Area	Slurry Height (ft)	Area (Acres)	Cut to Fill	Volume of Fill (yd^3)	Volume of Cut (yd^3)
1	1.5	28	1.5	53,038	79,557
2	1.5	108	1.5	228,241	342,362
3	1.8	282	1.5	937,441	1,406,162
Totals		**418**		**1,218,720**	**1,828,080**

Table 5: Summary of Creation Acreage and Volume

Though the initial fill elevations for Marsh Creations 1, 2 and 3 will be +2.0 ft, +2.0 ft, and +2.5 ft respectively, volume calculations were determined at a slurry height elevation lower than the initial constructed fill elevation to allow for primary consolidation settlement of the fill. As shown in the settlement curves in Figures 10 and 11, the fill elevation decreases at a much quicker rate within the first few years after construction as compared to the mid to later years due to the draining of the excess pore water. Midway between onset and completion of primary consolidation settlement, the material has a chance to mostly dewater giving a more accurate estimate of the actual volume of the dredged material needed to achieve the target marsh elevation.

8.2 Earthen Containment Dike Design

The primary design parameters associated with the earthen containment dike design include marsh fill elevation, crown elevation, crown width, and side slopes. One foot of freeboard will be used to contain the dredge slurry within the marsh creation areas. Therefore, the earthen containment dikes will be constructed to an elevation between 3.0 and 3.5ft NAVD88.

The width of the crown of the earthen containment dikes provide a minimum factor of safety of 1.5 in regards to bearing capacity. All outer earthen containment dikes will be constructed using crown width of 5 feet. A side slope of 4 feet horizontal for every foot of vertical rise (4H:1V) was utilized for containment of the marsh creation areas.

The earthen containment dikes for marsh creation areas 1 and 2 will be constructed using in-situ material from inside the marsh creation fill areas. A 2H:1V side slope will be necessary in the earthen containment dike borrow area for cells 1 and 2. For slope stability purposes, the dike borrow pits will be located a minimum of 20 feet from the toe of the containment dike. The containment borrow pit for marsh creation sites 1 and 2 have a maximum bottom elevation of -5.0 ft, NAVD88. The earthen containment dikes for marsh creation area 3 will be constructed using in-situ material from either outside and inside the marsh creation area for reasons discussed in Section 7.2.2. Similarly, for the purposes of slope stability the dike borrow pit will be located at a minimum of 20 feet from the toe of the dike. For all marsh fill cell containment, a berm of larger than the minimum 20 feet from the toe of the dike may be used if the equipment has the allowable reach. A 4H:1V side slope will be used in the earthen containment dike borrow area that will be borrowed from the outside of the marsh creation fill area with a maximum bottom elevation of -5.0 ft, NAVD88. For the interior earthen containment dike borrow portion, a 2H:1V side slope and a maximum bottom elevation of -5.0 ft, NAVD88 will be used to construct the earthen containment dikes. Typical sections of the marsh creation containment dikes are shown below in Figures 17, 18 and 19.

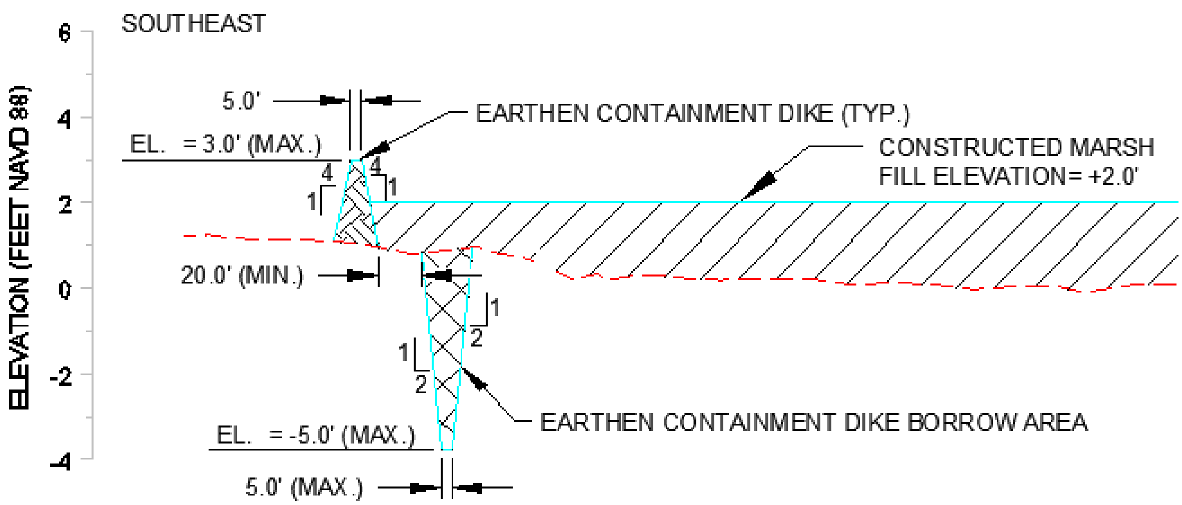


Figure 17: Typical earthen containment dike section for Marsh Creation Fill Areas 1&2.

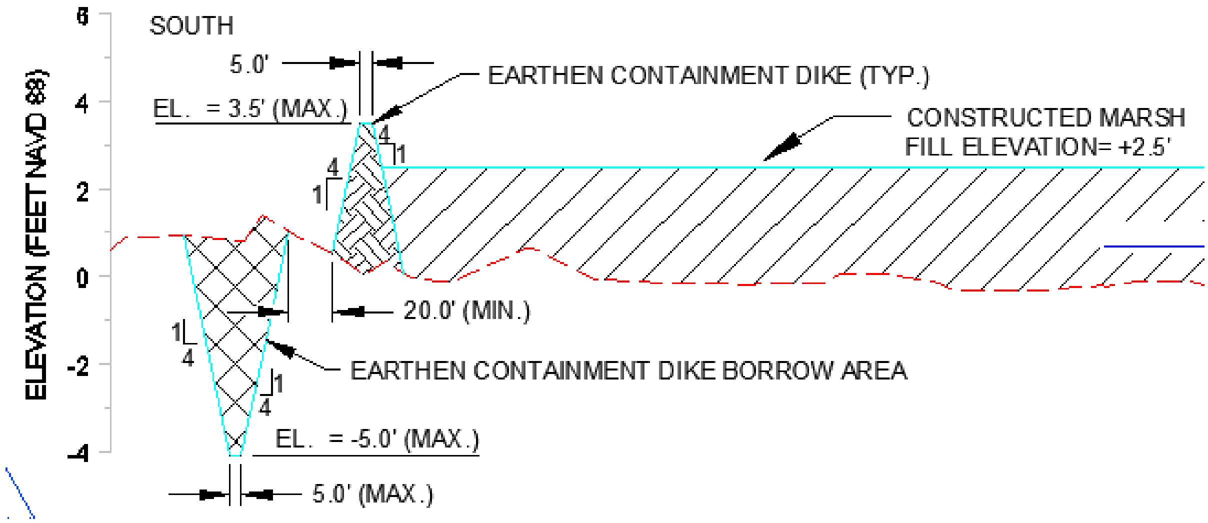


Figure 18: Typical earthen containment dike section for borrowing outside of Marsh Creation Fill Area 3.

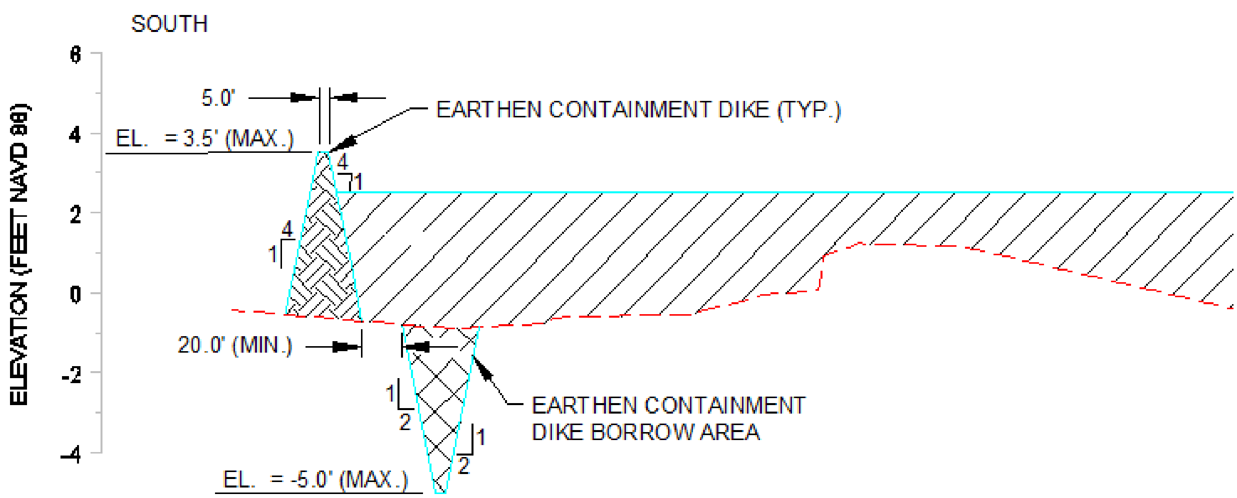
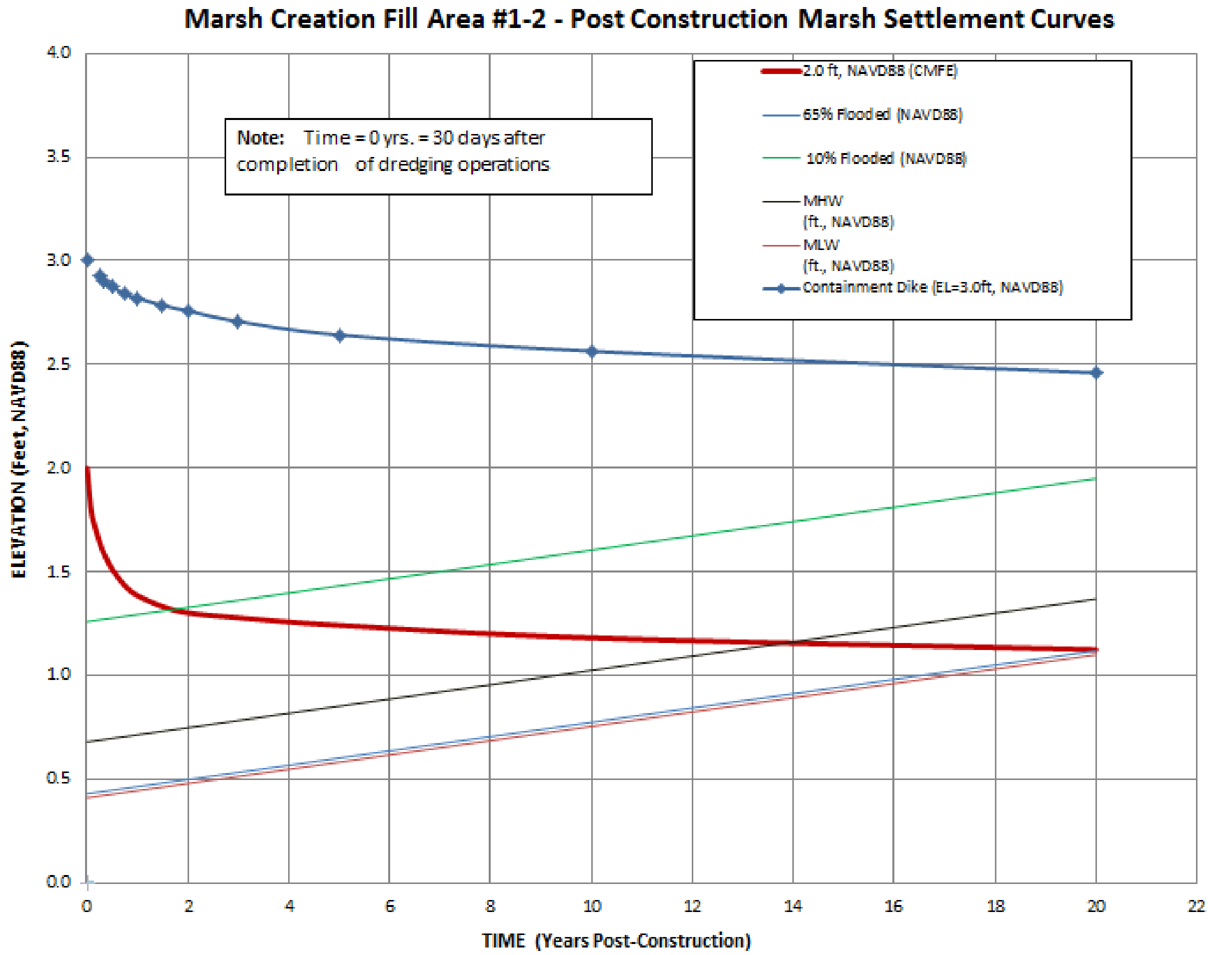


Figure 19: Typical earthen containment dike section for borrowing within Marsh Creation Fill Area 3.

As discussed in Section 6.5, settlement of the soils beneath the earthen containment dikes was computed based on the dike geometries. The settlement curves for the final dike geometries and elevations are shown in Figures 19 and 20. The results show that a minimum of one (1) foot of freeboard will be present at all times during construction and throughout the 20 year project design life.



Figures 20: Earthen Containment Dike estimated settlement curve.

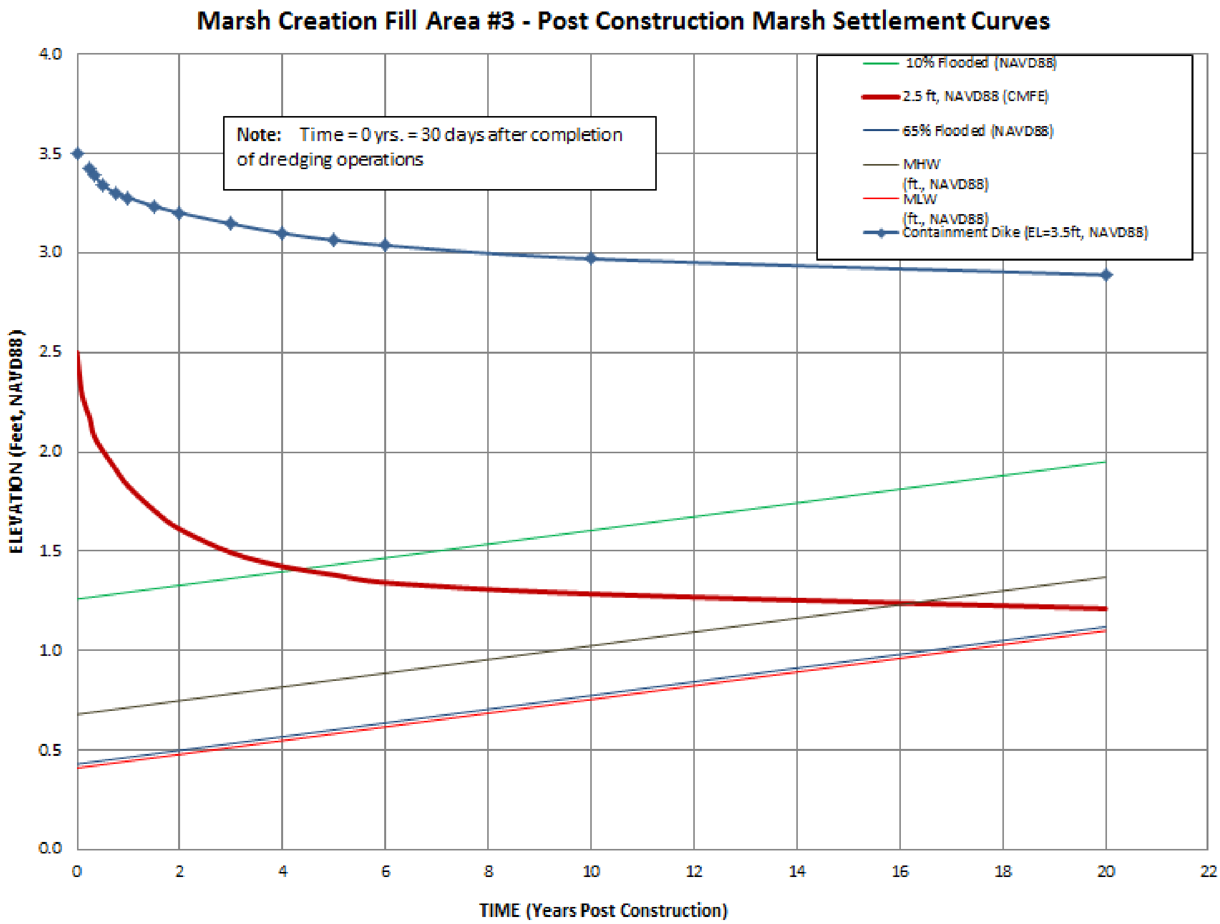


Figure 21: Earthen containment dike estimated settlement curve.

Table 7 details the design aspects of the earthen containment dikes.

Marsh Creation Area	Design Height (ft)	Side Slopes	Crown Width (ft)	Factor of Safety	Minimum Offset (ft)	Cut to Fill	Volume of Fill (yd^3)	Volume of Cut (yd^3)
1	3.0	4H : 1V	5	2.02	20	1.3	7,244	9,417
2	3.0	4H : 1V	5	3.97	20	1.3	9,226	11,994
3	3.5	4H : 1V	5	1.61	20	1.3	54,337	70,638
Total							**70,807**	**92,049**

Table 6: Summary of Earthen Containment Dike Design

8.3 Borrow Area Design

The controlling factors in the proposed borrow area design are the location, size, and depth. It is preferred that the borrow area be located in close proximity to the marsh creation fill areas in order to minimize the pumping distance of material. It is also preferred that the borrow area be clear of any existing oyster leases or pipelines. The borrow area chosen during the Phase 0 stage of the project satisfies these criteria.

The size of the borrow area is determined by the total volume of marsh fill required for the project and provide sufficient latitude for the contractor to select the most effective area to dredge and move within. A cut to fill ratio should be applied when placing hydraulically dredged material. This is to account for any lost material during the dredging and dewatering processes of construction. Under normal circumstances, it takes approximately 1.3 to 1.5 cubic yards of hydraulically removed material to fill 1.0 cubic yards in the placement area. For TV-63, a 1.5:1 cut to creation ratio was applied to determine the cut volume in the borrow area. A summary of in-place fill and cut volumes for each marsh creation area is found in Table 5 in Section 8.1.

An elevation of -15 feet, NAVD88 was chosen to be the maximum bottom elevation to ensure there would be enough material available. The borrow area chosen during the Phase 0 stage of the project has an area of 193 acres. Due to finding the unknown pipeline discussed in Section 5.5 in such close proximity to the borrow area, the geometry of the borrow area was changed to the shape reflected in Figure 18. The new geometry maintained the 193 acres of borrow area by offsetting the southwest quadrant 100 feet from the unknown pipeline and extending the western edge. Cross-sectional areas of each transect in the borrow area were calculated using the data collected in the borrow area survey to compute average end area. The available volume of material within this borrow area was then calculated using these areas. The chosen borrow area has approximately 3.2 million cubic yards of material. For additional information refer to the detailed soil boring logs for B19-B24 in Appendix C.

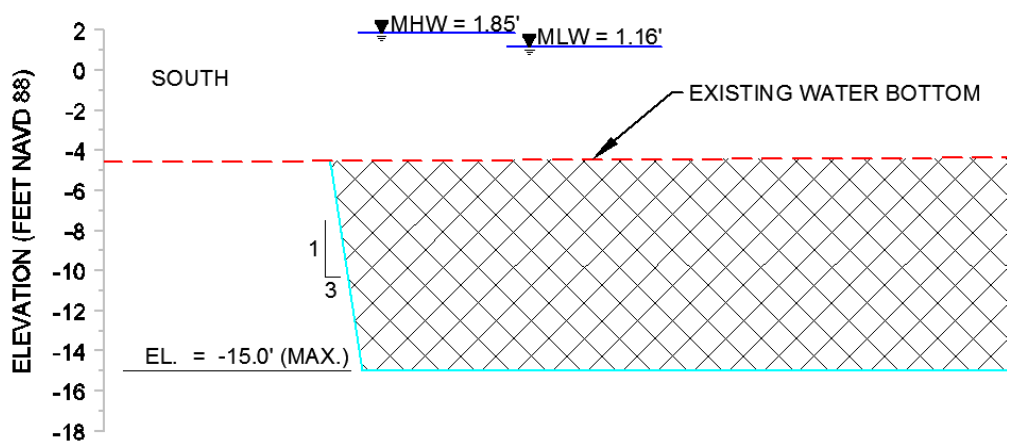


Figure 22: Borrow Area typical section.

A borrow area wave refraction analysis has not been performed for this borrow area because of the location in Little Vermilion Bay. If required to secure a construction permit, all necessary data has been collected to run the analysis.

8.4 Equipment Access Corridor Design

Since the bottom elevations in Little Vermilion Bay are approximately -3.0 ft to -4.0 ft, NAVD88 on average, equipment access dredging will be needed to get the necessary equipment to the borrow area. Figure 18 shows the route for access starting from Freshwater Bayou and continuing down the centerline of the TV-12 (Little Vermilion Bay Terraces) project into Little Vermilion Bay. Once in Little Vermilion Bay, oil and gas infrastructure and previously dredged routes dictated the alignment of the corridor.

A dredge having a discharge diameter of no bigger than 27 inches was assumed to be the size necessary to perform this work. With this in mind, the maximum bottom elevation will be dredged to a -9 ft, NAVD88 with a 3:1 side slope and a 70 ft maximum bottom width as shown in Figure 22. A maximum bottom elevation of -9 ft, NAVD88 would result in approximately 10 ft of draft. Approximately 220,000 CY of dredged material will be placed as temporary spoil and backfilled upon the completion of the project. The spoil placement will start no closer than 25 feet from the edge of cut for slope stability purposes.

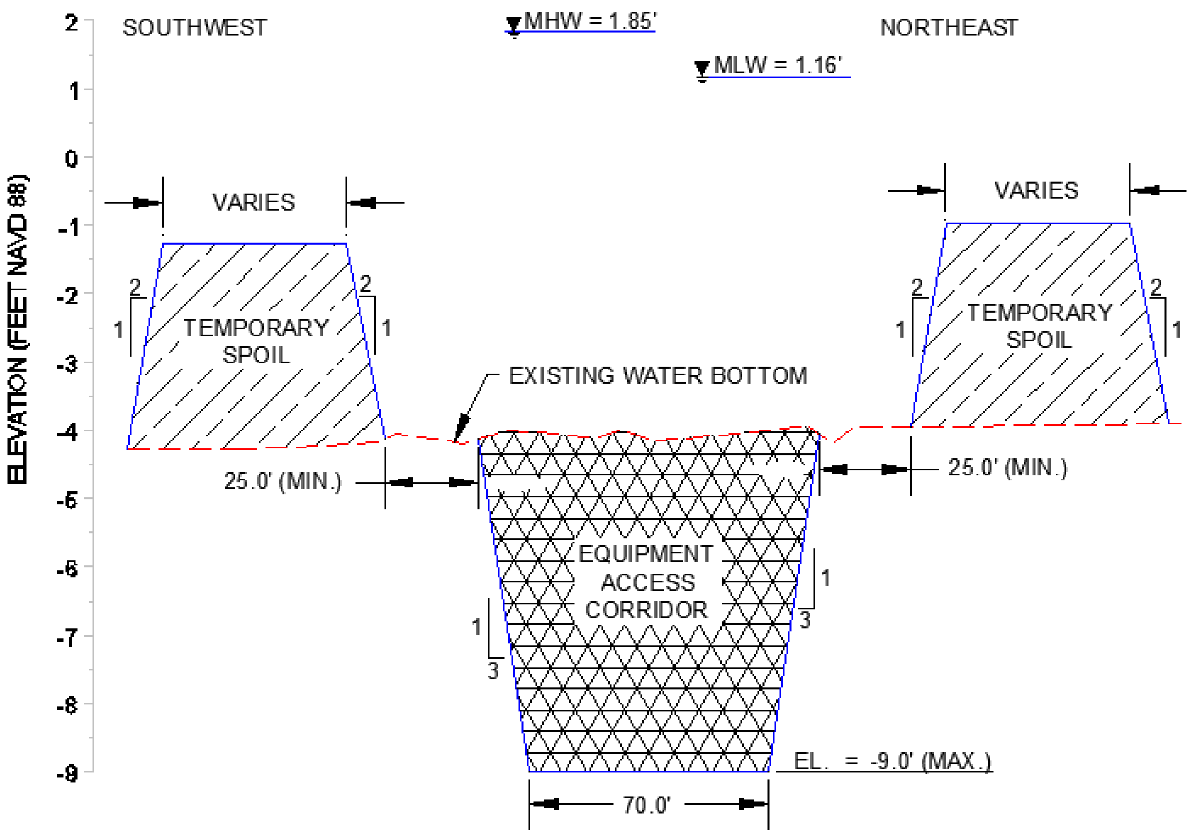


Figure 23: Typical section for the equipment access corridor.

8.4.1 Pipeline Crossing- Offshore

Due to the presence of the 10 inch Acadian pipeline crossing the Equipment Access Corridor discussed in Section 5.3, special care needs to be taken when dredging the equipment access corridor. According to the Federal Regulation Title 49 Section 195.248, a depth of cover of four (4) feet needs to maintained over the line at all times in inland bodies of water. Limiting the dredge size ensures sufficient draft will be available to safely float the equipment across the pipeline without impacting the water bottom while still maintaining the prescribed four (4) feet of cover.

8.5 Dredge Pipeline Alignment

The dredge pipeline alignment will not only serve as a pathway for laying the dredge pipe from the dredge to the marsh fill areas, but it will also provide a route for moving the necessary equipment to construct the marsh creation fill areas. Figure 24 details the alignment as well as approximate lengths of each reach.

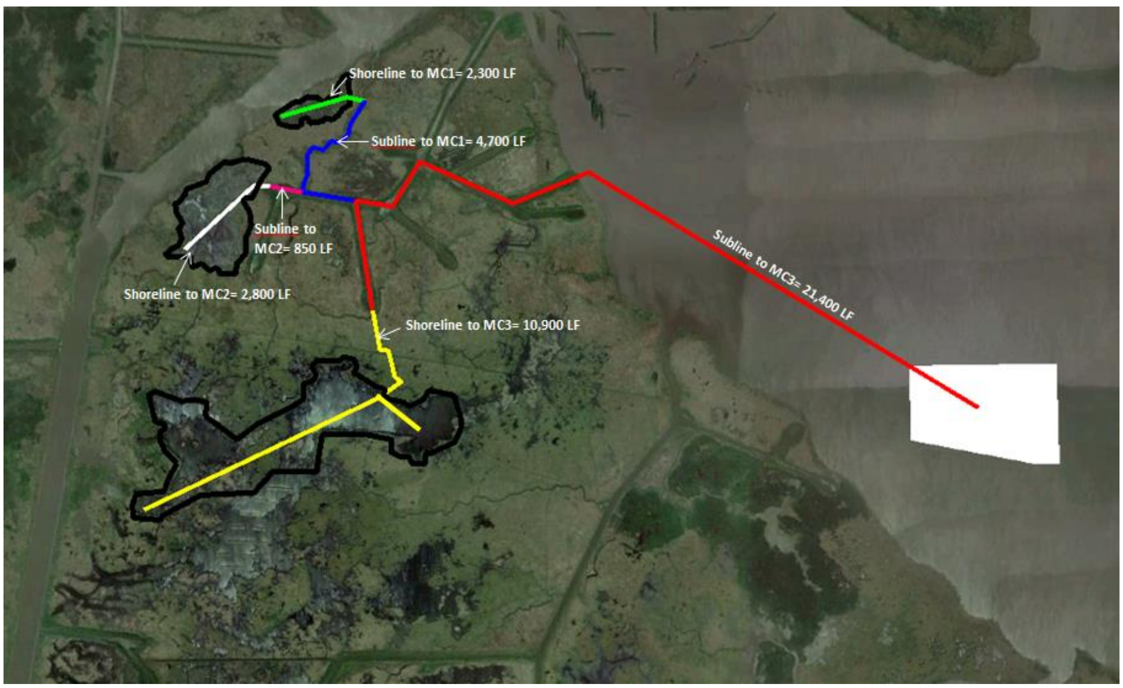


Figure 24: Dredge Pipeline Alignment and approximate pipe lengths.

The major considerations that were taken into account with delineating the alignment were ease of access and limiting the impact to existing healthy marsh. With the exception of the three marsh creation fill areas, the marsh found in the project area is relatively healthy. Taking that into consideration, the dredge pipeline alignment was designed so as to follow the oil field canals and existing trenasses where applicable.

8.5.1 Pipeline Crossings - Cole's Bayou and Unknown Pipeline

Just as with the crossing in Little Vermilion Bay, special care needs to be taken to lay the dredge pipeline and mobilize and demobilize the equipment necessary to construct Marsh Creation Fill Area 1. Since the depth of cover over the pipeline is only about 5 feet in Cole's Bayou, the dredge pipeline will be floated across the line so as not to disturb the soil. Pontoons will be placed on either side of the crossing as shown in Figure 25, and the dredge pipeline will be encased to ensure it stays in place throughout the construction of Marsh Creation Fill Area 1. All equipment necessary to construct fill area 1 will be mobilized and demobilized through Freshwater Bayou so as to not cross the Acadian pipeline.

Similar methodology that will be used to cross the Acadian pipeline will be used to cross the Unknown pipeline in the vicinity of Marsh Creation Fill Area 3. This pipeline also has approximately five (5) feet of cover, so the dredge pipeline will be floated over it so as not to disturb the underlying soils. Equipment needed to construct fill area 3 will be mobilized and demobilized through an adjacent channel shown on the Plans.

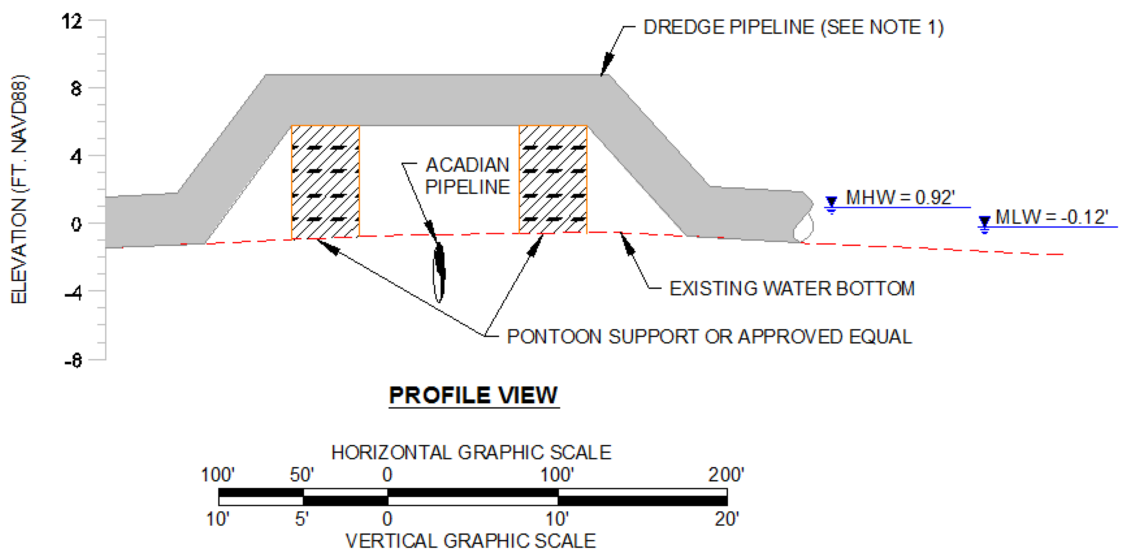


Figure 25: Dredge pipeline crossing profile.

9.0 HYROLOGIC RESTORATION DESIGN

The project proposes to restore the hydrology in the project area by installing water control structures on the northern and southern boundaries as shown in Figure 18, and dredging a conveyance channel along the eastern boundary of the largest marsh creation fill cell. The hydrologic restoration design was broken into two (2) components: the water control structures and the conveyance channel. The design of each component is discussed in the sections below.

9.1 Water Control Structure Design

The primary goal of the water control structures is to control the volume of water getting into the project area and to facilitate the egress of the water to the south. The water control structures should also aid in establishing unidirectional flow from north to south. These goals governed the placement and configuration of the water control structures. Though the project area is largely enclosed by an existing dike, there are many breaches found in the northern boundary of the project area that allow water to get into the system. These breaches are not found in the southern boundary, so any water getting into the project area is trapped causing interior ponding. The locations of the breaches, existing channels, and larger ponding areas dictated the locations of the water control structures.

Scientists for both CPRA and NMFS were concerned with ensuring the flow would only be north to south to prevent any back flow into the marsh. To accomplish this, the water control structures will be fitted with check valves that allow water to only flow in one direction.

Since the breaches ranged in widths of 5 feet to 30 feet across and the area is home to many species of wildlife, the water control structures needed to be sized in a way so as to accommodate these factors. Forty-eight (48) inch corrugated HDPE water control structures were initially proposed to achieve this goal. Upon further investigation into the actual water levels present as well as the need to accommodate wildlife, forty-two (42) inch corrugated metal pipes were determined to be more cost effective while still achieving the goals set forth for the hydrologic restoration component of the design. The corrugated metal pipe was preferred over the HDPE pipe originally proposed because of its ability to better withstand potential marsh fires than the plastic pipe.

In order to account for the reduction in flow from the 48 inch pipe to the 42 inch pipe, additional pipes were added at existing locations in both the northern and southern reaches of the project area. One additional pipe was added in the southern reach to provide extra drainage capacity.

Due to the varying water depths associated with the breaches in the northern extent of the project area, different installation methods will be needed at some of the breach locations. For shallow breaches (depth >4 feet), in-situ material will be used to encase the water control structures and bring the levees back to existing grade. The Contractor will be required to compact the in-situ soil prior to placing the corrugated metal pipe to help limit any differential settling. Figure 26 shows a typical of a shallow breach water control structure in place. In areas with deeper water depths (<4 feet), a closure structure will be necessary to keep the pipe(s) in place. Sand will be used to fill breaches to the pipe invert elevation of -2 feet, NAVD88, and the pipe(s) will be capped with in situ soil to allow for a depth of cover of one (1) foot over the pipe. PZ-35 steel sheet piles will be driven to a maximum depth of -35 feet, NAVD88 within the breach to provide stability for the pipe(s) while also closing the breach. Geotechnical engineering programs such as CWALSHT and PileBuck were used to calculate the minimum penetration depth for the sheet piles. A detailed description of the model runs performed and the results of those runs can be found in Appendix H. Sheet pile will also be used to tie the structure in to the existing dike. Through the use of the engineering programs, a minimum embedment of 10 feet into the existing dike was calculated. The sheet pile will be driven to an elevation of -15 feet NAVD88 to account for unknown variations in ground surface elevation and soil. Figure 27 shows a typical of a deep breach water control structure in place.

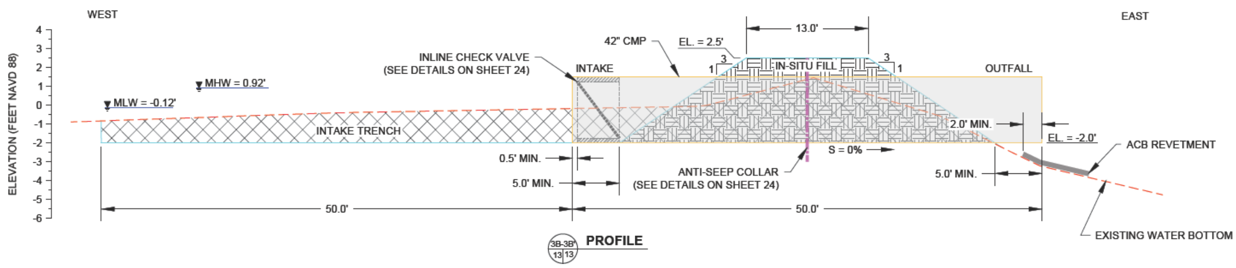


Figure 26: Example of water control structure backfilled with in-situ material.

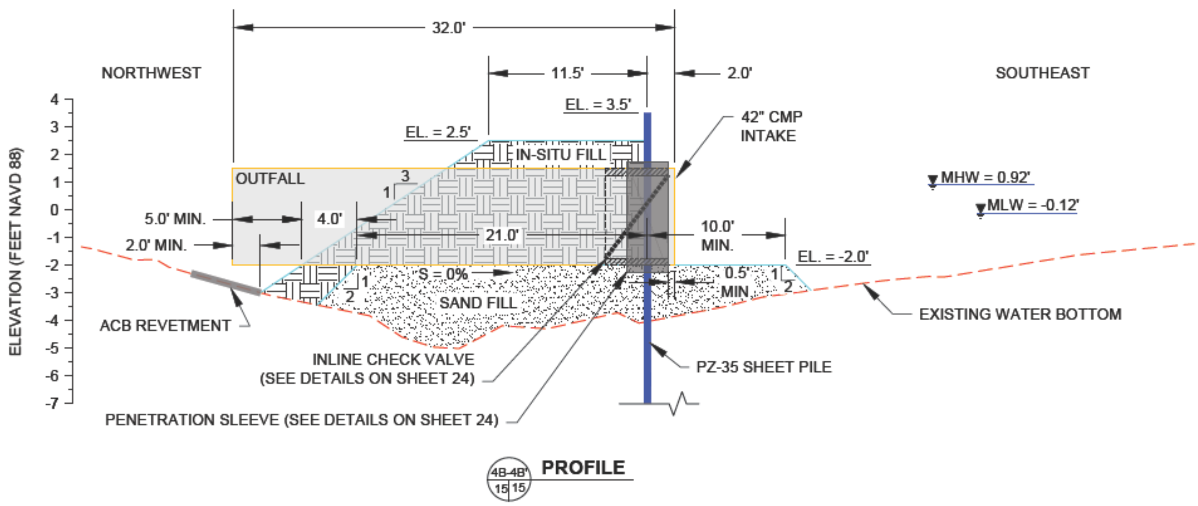


Figure 27: Example of water control structure with sheet pile closure.

Water control structure locations in the southern part of the project area and along Cole's Bayou have an existing dike in place. The Contractor will be required to excavate a trench to place the pipes and backfill that material to existing grade keeping a minimum of one (1) foot of cover over the pipes. All pipes installed at locations without sheet pile will be fitted with an anti-seep collar so as to minimize scour around the pipe. Articulated concrete block revetments will be installed at the outfall end of each of the twelve (12) water control structure locations to minimize scour at the outfalls.

In many of the water control structure locations, earthwork will be necessary to install the corrugated metal pipe(s). Intake an outfall channels will be excavated to a -2 foot, NAVD88 a maximum distance of fifty (50) feet from either the intake or the outfall side of the corrugated metal pipe(s) to help create a pathway for the water through the pipe(s). Material excavated from these channels will be used as backfill for the pipe(s), and any excess material will be evenly spread just behind the existing earthen dike. In the case where the volume of material excavated for the channels is insufficient to backfill the pipe(s), material will be borrowed from a borrow area within the oil field canals as shown in the Plans.

9.1.1 One-Way Check Valve

As stated in Section 9.1, one goal of the hydrologic restoration component of the design is to ensure flow would only be from north to south. To achieve this, both flap gates and check valves were evaluated to determine which option would work best in this environment.

Different factors such as cost, ability to impede back flow, weight of gate or valve, and ease of maintenance were considered. It was determined that while the traditional steel flap gate structure did successfully impede back flow, the rigid gate would greatly increase the maintenance needed on the structure because any small amount of debris could decrease the functionality of the gate by either keeping it open all the time or keeping it closed all the time. Since the project area is assessable by boat only, the project team would like to keep minimize the frequency of maintenance events.

Two options for check valves were evaluated for use on this project, a duck bill option and an inline check valve option. Both options blocked back flow into the marsh, and both valves are made of flexible material that has the capabilities to seal around small amounts of debris allowing the valve to remain functional. However, the inline check valve has the advantage of being able to be installed inside of the pipe whereas the duck bill check valve can only be installed on one of the ends of the pipe. Being able to install the valve within the pipe allows for protection of the valve making it less likely to be damaged.

9.2 Conveyance Channel

As stated in Section 8.2 (Earthen Containment Dike Design), the borrow material for the containment dike of the largest marsh creation fill area (Marsh Creation Fill Area 3) will be partially taken from outside of the marsh creation fill area. The channel will start at the intersection between Cole's Bayou and Marsh Creation Fill Area 3 and will follow the eastern extents of the fill area to the terrace field just to the south of the fill area. This will help to reconnect existing trenasses and channels that will be cut off once the marsh fill is placed. Dimensions for the conveyance channel are 25 ft wide top width by 5 ft deep, and a typical can be found in Figure 20 in Section 8.2. It will utilize the 4:1 side slope prescribed by Ardaman and Associates for slope stability purposes.

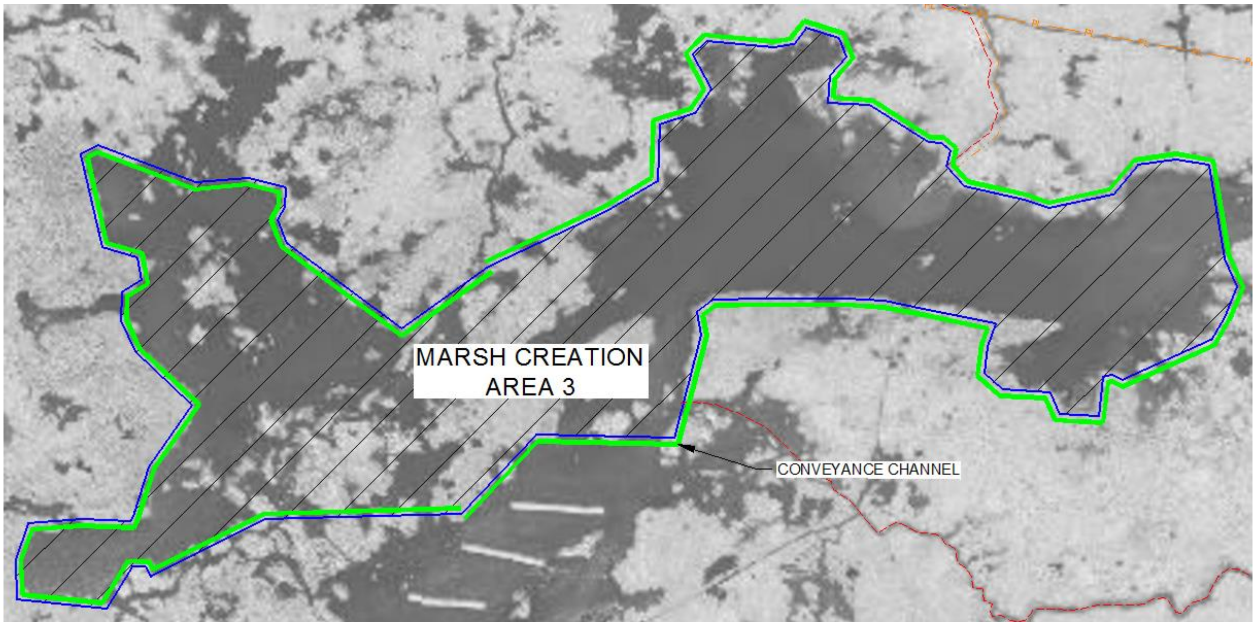


Figure 28: Plan view of the conveyance channel around marsh creation fill area 3.

10.0 CONSTRUCTION

10.1 Duration

An approximate construction duration was developed using the CDS Dredge Production and Cost Estimation Software and Microsoft Project. Assuming construction of the containment dikes will be completed prior to dredging, the time to complete containment dike construction and to fill marsh creation cells would be approximately 6 months using a 27 inch dredge and incorporating weather days. Water control structure installation including earthwork and weather days would be performed concurrently and take approximately 4 months.

11.0 MODIFICATIONS TO APPROVED PHASE 0 PROJECT

As a result of Phase 1 activities, the features originally approved in Phase 0 have been modified to present a more cost effective and competitive project for consideration of Phase II funding. Specifically, the northern reach of Cole's Bayou was intended to be dredged to promote north of south flow through the project area. However, the input into the system provided by the oilfield canals is greater than previously estimated based on subsequent hydrodynamic modeling. Therefore, dredging Cole's Bayou would create an unnecessary expense for the project and is no longer included as a project feature.

12.0 REFERENCES

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Appendix A:
Secondary Monument Data Sheets and CRMS Survey Reports

Appendix B: HydroTerra, Inc. Magnetometer Survey Drawings

Appendix C:
Ardaman Boring Logs

Appendix D:
Preliminary Cultural Resources Determination

Appendix E:
Preliminary Design Drawings

Appendix F:
Calculations Package

Appendix G:
Dynamic Solutions Final Modeling Report

Appendix H:
Summary of Sheet Pile Design Runs

Appendix I: Responses to 30% Design Comments